

## THIOPHENE AND FURAN COMPOUNDS

### BACKGROUND OF THE INVENTION

Glutamate is the major excitatory neurotransmitter in the central nervous system.

5 Three glutamate receptor ion channel subtypes have been identified based on their sensitivity to the selective activators (agonists) N-methyl-D-aspartate (NMDA),  $\alpha$ -amino-3-hydroxy-5-methyl-4-isoxazole propionic acid (AMPA), and kainate.

AMPA receptors mediate cellular responses to glutamate by direct and indirect mechanisms. When activated by glutamate or AMPA, AMPA receptor ion channels  
10 allow sodium ions ( $\text{Na}^+$ ) and calcium ions ( $\text{Ca}^{2+}$ ) to pass directly through the channel pore. In addition, AMPA receptor ion channels can facilitate the activation of NMDA receptors by initiating cellular depolarization that relieves magnesium ion ( $\text{Mg}^{2+}$ )-dependent block of NMDA receptors.

Multiple AMPA receptor subtypes have been identified and cloned: GluR1,  
15 GluR2, GluR3, and GluR4 as disclosed by Hollmann and Heinemann, *Ann. Rev. Neurosci.*, 17, 31-108 (1994). Each subunit consists of a sequence of approximately 900 amino acids. Four subunits are thought to assemble to form a tetrameric ion channel complex with the functional properties of this ion channel most likely being determined by its subunit composition.

20 Ion channel currents activated by glutamate via AMPA receptors are transient. The time course of currents is modified by refractory states caused during glutamate binding which is referred to as desensitization and by the rate of glutamate removal from the ion channel binding site which results in deactivation. Ion influx through AMPA receptors may be enhanced by compounds that either prevent desensitization or by  
25 compounds that slow deactivation rates. Compounds that enhance glutamate-stimulated ion influx at AMPA receptors are known as positive AMPA receptor allosteric modulators or AMPA receptor potentiators. One such compound, which selectively potentiates AMPA receptor function, is cyclothiazide. Since AMPA receptors play a  
30 pivotal role in mediating fast excitatory transmission in the central nervous system, molecules that enhance AMPA receptor function have multiple therapeutic targets.

Compounds that allosterically potentiate AMPA receptors have been shown to enhance synaptic activity *in vitro* and *in vivo* as disclosed, for example, by I. Ito, et al., *J.*

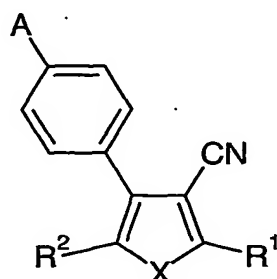
*Physiol.*, 424, 533-543 (1990) and A. Copani, et al., *Journal of Neurochemistry*, 58, 1199-1204 (1992). Such compounds have also been shown to enhance learning and memory in rats, monkeys, and humans, and are reviewed by Gouliaev and Senning, *Brain Research Reviews*, 19, 180-222 (1994).

5 International Patent Application Publication WO 98/33496 published August 6, 1998 discloses certain sulfonamide derivatives which are useful, for example, for treating psychiatric and neurological disorders, for example cognitive disorders, Alzheimer's disease, age-related dementias, age-induced memory impairment, tardive dyskinesia, Huntington's chorea, myoclonus, Parkinson's disease, reversal of drug-induced states  
10 (such as cocaine, amphetamines, alcohol-induced states), depression, attention deficit disorder, attention deficit hyperactivity disorder, psychosis, cognitive deficits associated with psychosis, and drug-induced psychosis. P.L. Ornstein, et al. *J. Med. Chem.*, 43, 4354 (2000) further disclose biarylpropylsulfonamides which are potent potentiators of AMPA receptors. In addition, X. Li, et al., *Neuropharmacology*, 40, 1028 (2001) disclose  
15 antidepressant-like actions of an AMPA receptor potentiators. D.D. Schoepp, et al. and Tizzano, et al., *Society for Neuroscience Abstracts*, 26(1-2), 528.19 and 528.20, 30<sup>th</sup> Annual Meeting, New Orleans, (November 4-9, 2000) disclose an orally active AMPA receptor potentiator that enhances spatial learning and memory performance in rats, and reverses both pharmacologically and age-associated learning and memory deficit in rats.

20 European Patent No. 0 273 602 discloses substituted 3-cyanothiophenes which are useful as herbicides. In addition, Luteijn and Wals, *Tetrahedron*, 44(18), 5921 (1988) disclose the synthesis of certain 3-cyanothiophenes, and Dehne and Krey, *Pharmazie*, 33(10), 687 (1978) disclose certain 4-phenyl-3-cyanothiophene derivatives.

## 25 SUMMARY OF THE INVENTION

The present invention provides a compound of Formula I:



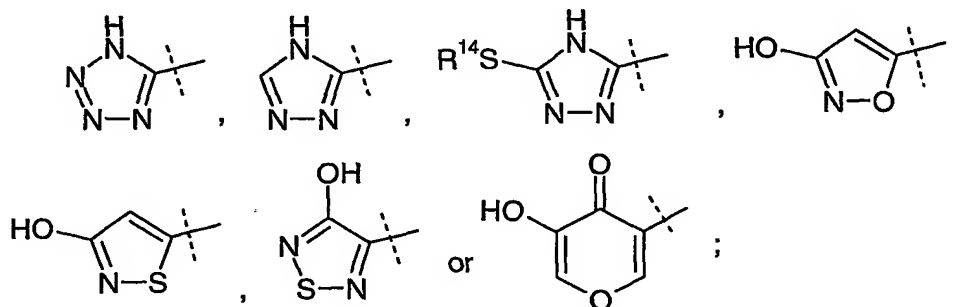
Formula I

wherein

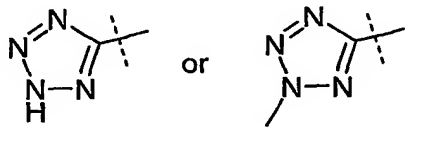
X represents S or O;

R<sup>1</sup> represents hydrogen, F, Cl, Br, I, CHO, -CN, -S(phenyl), CF<sub>3</sub>, -(1-4C)alkyl, -(1-4C)alkoxy, -S(1-4C)alkyl, -SO(1-4C)alkyl, -SO<sub>2</sub>(1-4C)alkyl, -C(=O)(1-3C)alkyl, NH<sub>2</sub>, -NH(1-4C)alkyl, -N[(1-4C)alkyl]<sub>2</sub>, -NH(4-7C)cycloalkyl, or -N[(1-4C)alkyl](CH<sub>2</sub>)<sub>r</sub>N[(1-4C)alkyl]<sub>2</sub>;

R<sup>2</sup> represents -CN, -CO<sub>2</sub>H, -C(=O)NHR<sup>13</sup>, -C(=O)NHOH, -C(=O)NHCN, -SO<sub>2</sub>OH, -SO<sub>2</sub>NH(1-4C)alkyl, -C(=O)NHSO<sub>2</sub>R<sup>19</sup>, -PH(=O)(OH), -P(=O)(OH)<sub>2</sub>, -P(=O)(OH)NH<sub>2</sub>, -P(=O)(OH)CH[(1-4C)alkoxy]<sub>2</sub>, -C(=O)NHSO<sub>2</sub>CF<sub>3</sub>, -C(=O)NHSO<sub>2</sub>CH<sub>2</sub>CF<sub>3</sub>,



R<sup>4</sup> represents hydrogen, OH, -CH<sub>2</sub>OH, -CH<sub>2</sub>CH<sub>2</sub>OH, -CH<sub>2</sub>O(1-4C)alkyl, F, Cl, CF<sub>3</sub>, OCF<sub>3</sub>, -CN, NO<sub>2</sub>, NH<sub>2</sub>, -CH<sub>2</sub>NH<sub>2</sub>, -(1-4C)alkyl, -(1-4C)alkoxy, -C(=O)NH(1-4C)alkyl, -C(=O)NH<sub>2</sub>, -CH<sub>2</sub>C(=O)NH<sub>2</sub>, -NHC(=O)(1-4C)alkyl, -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>10</sup>, -(CH<sub>2</sub>)<sub>n</sub>CN, -(CH<sub>2</sub>)<sub>m</sub>CO<sub>2</sub>H, -C(=NOH)CH<sub>3</sub>, -(CH<sub>2</sub>)<sub>m</sub>CO<sub>2</sub>(1-6C)alkyl, -C(=O)H, -C(=O)(1-4C)alkyl, -NH(1-4C)alkyl, -N[(1-4C)alkyl]<sub>2</sub>, -SR<sup>10</sup>, -SOR<sup>10</sup>, -SO<sub>2</sub>R<sup>10</sup>, SH, -CH<sub>2</sub>SO<sub>2</sub>NH<sub>2</sub>, -CH<sub>2</sub>NHC(=O)CH<sub>3</sub>,



R<sup>5</sup> represents hydrogen, F, Cl, -CN, NO<sub>2</sub>, NH<sub>2</sub>, -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>10</sup>, -(1-4C)alkyl, or -(1-4C)alkoxy;

R<sup>6</sup> represents hydrogen, -(1-4C)alkyl, -SO<sub>2</sub>R<sup>11</sup>, or -C(=O)(1-4C)alkyl;

R<sup>7</sup> represents hydrogen or -(1-4C)alkyl;

R<sup>8</sup> represents hydrogen, F, Cl, Br, -(1-4C)alkyl, -(1-4C)alkoxy, NO<sub>2</sub>, NH<sub>2</sub>, -CN, -NHSO<sub>2</sub>R<sup>11</sup>, or -C(=O)(1-4C)alkyl;

R<sup>8a</sup> represents hydrogen, F, Cl, Br, -(1-4C)alkyl, NO<sub>2</sub>, NH<sub>2</sub>, NH(1-6C)alkyl, N[(1-6C)alkyl]<sub>2</sub>, -C(=O)NH<sub>2</sub>, -CN, -CO<sub>2</sub>H, -S(1-4C)alkyl, -NHCO<sub>2</sub>(1-4C)alkyl, -C(=O)NHCH<sub>2</sub>CH<sub>2</sub>CN, or -C(=O)(1-4C)alkyl;

R<sup>10</sup>, R<sup>11</sup>, and R<sup>12</sup> each independently represent -(1-4C)alkyl, -(CH<sub>2</sub>)<sub>3</sub>Cl, CF<sub>3</sub>, NH<sub>2</sub>,

5 NH(1-4C)alkyl, N[(1-4C)alkyl]<sub>2</sub>, thienyl, phenyl, -CH<sub>2</sub>phenyl, or -(CH<sub>2</sub>)<sub>2</sub>phenyl, wherein phenyl, as used in substituent R<sup>10</sup>, R<sup>11</sup> or R<sup>12</sup>, is unsubstituted or substituted with F, Cl, Br, CF<sub>3</sub>, -(1-4C)alkyl, -(1-4)alkoxy, or acetyl;

R<sup>13</sup> represents hydrogen, -(1-4C)alkyl, -CH<sub>2</sub>CF<sub>3</sub>, triazole, or tetrazole;

R<sup>14</sup> represents -(1-4C)alkyl;

10 R<sup>15</sup> represents hydrogen or -(1-4C)alkyl;

R<sup>19</sup> represents (1-4C)alkyl or CF<sub>3</sub>;

m represents 0, 1, 2, or 3;

n represents 1, 2, 3, or 4;

p represents 1 or 2;

15 r represents 1 or 2; and

A is selected from the group consisting of -OH, Br, I, CF<sub>3</sub>, -(CH<sub>2</sub>)<sub>m</sub>CN, -C(CH<sub>3</sub>)<sub>2</sub>CN, NO<sub>2</sub>, NH<sub>2</sub>, -O(CH<sub>2</sub>)<sub>n</sub>NH<sub>2</sub>, -O(CH<sub>2</sub>)<sub>n</sub>NHSO<sub>2</sub>(1-4C)alkyl, -O(CH<sub>2</sub>)<sub>n</sub>SO<sub>2</sub>(1-4C)alkyl, -C(=O)NH(CH<sub>2</sub>)<sub>r</sub>NHSO<sub>2</sub>(1-4C)alkyl, -S(1-4C)alkyl,

-(1-6C)alkyl, -(1-4C)alkoxy, -(2-4C)alkenyl, -(2-4C)alkenyloxy, -CO<sub>2</sub>H,

20 -CO<sub>2</sub>(1-4C)alkyl, -CHO, -C(=O)(1-4C)alkyl, -C(=O)NH<sub>2</sub>, -C(=O)NH(1-6C)alkyl, -C(=O)NR<sup>15</sup>(CH<sub>2</sub>)<sub>m</sub>phenyl wherein phenyl is unsubstituted or substituted with one or two substituents independently selected from the group consisting of OH, F, Cl, Br, I, NO<sub>2</sub>, NH<sub>2</sub>, -NHSO<sub>2</sub>(1-4C)alkyl, -CN, -(1-4C)alkyl, and -(1-4C)alkoxy; -OSO<sub>2</sub>CF<sub>3</sub>, -O(CH<sub>2</sub>)<sub>n</sub>CN, -NHC(=O)(1-4C)alkyl, -NHC(=O)(CH<sub>2</sub>)<sub>m</sub>phenyl wherein phenyl is

25 unsubstituted or substituted with one or two substituents independently selected from the group consisting of OH, F, Cl, Br, I, NO<sub>2</sub>, NH<sub>2</sub>, CN, -(1-4C)alkyl and -(1-4C)alkoxy; -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>12</sup>, -CH(CH<sub>3</sub>)(CH<sub>2</sub>)<sub>p</sub>NHSO<sub>2</sub>R<sup>12</sup>,

-(CH<sub>2</sub>)<sub>p</sub>CH(CH<sub>3</sub>)NHSO<sub>2</sub>R<sup>12</sup>, -NH(CH<sub>2</sub>)<sub>m</sub>phenyl wherein phenyl is unsubstituted or

substituted with one or two substituents independently selected from the group consisting

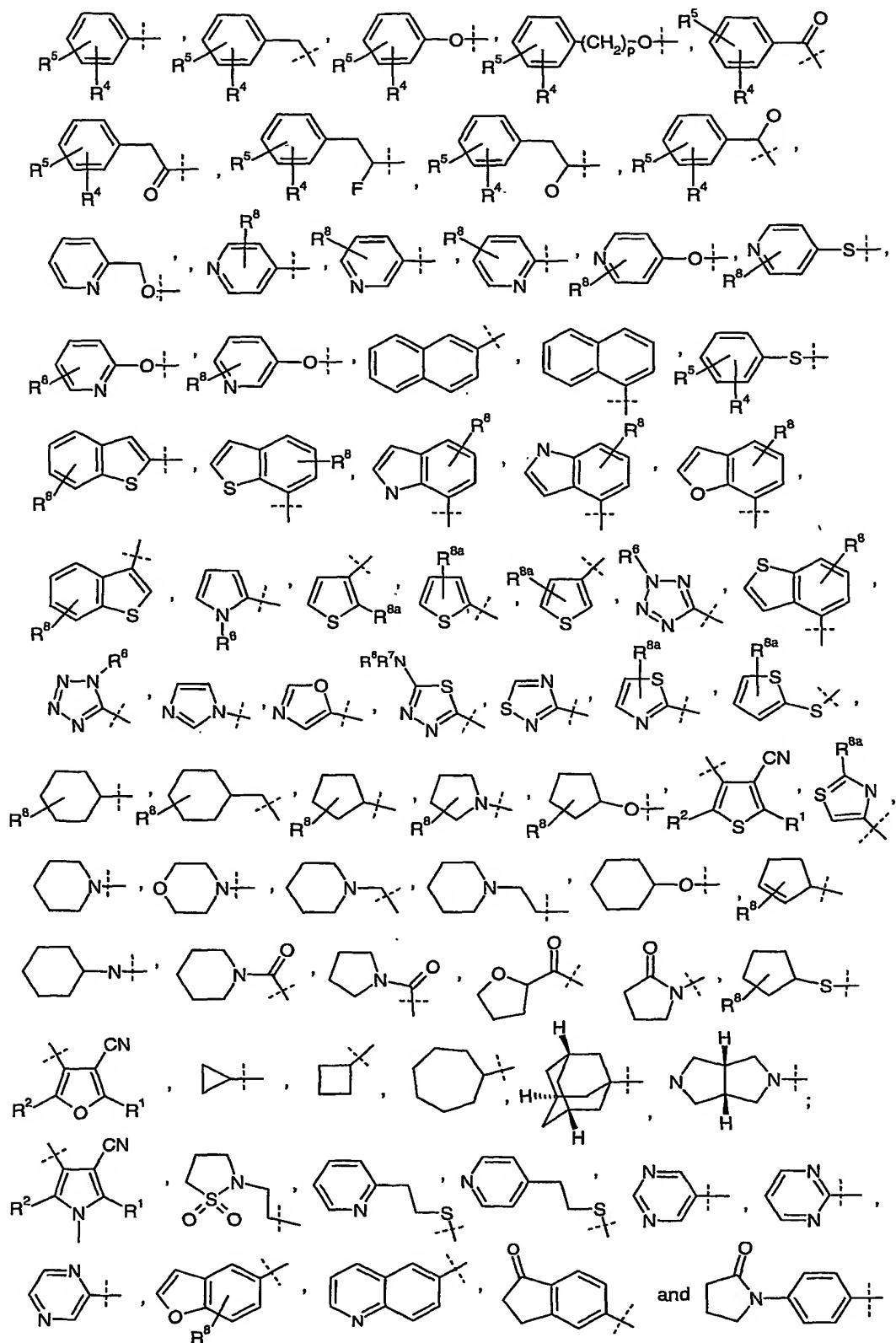
30 of OH, F, Cl, Br, I, NO<sub>2</sub>, NH<sub>2</sub>, CN, -(1-4C)alkyl, and -(1-4C)alkoxy; -NH(1-4C)alkyl,

-N[(1-4C)alkyl]<sub>2</sub>, -C(=O)NH(3-6C)cycloalkyl, -C(=O)NH(CH<sub>2</sub>)<sub>n</sub>N[(1-4C)alkyl]<sub>2</sub>,

-C(=O)NH(CH<sub>2</sub>)<sub>n</sub>NH(1-4C)alkyl, -(CH<sub>2</sub>)<sub>n</sub>NH<sub>2</sub>, -O(CH<sub>2</sub>)<sub>n</sub>SR<sup>14</sup>, -O(CH<sub>2</sub>)<sub>n</sub>OR<sup>14</sup>,

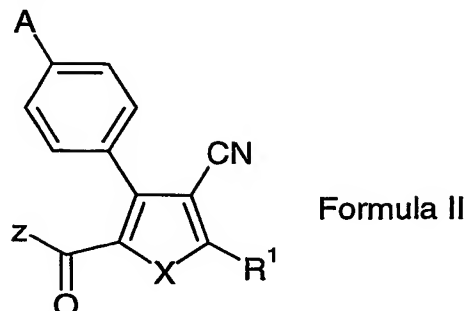


$-(CH_2)_nNHR^{12}$ ,  $-(CH_2)_nNH(3-6C)cycloalkyl$ ,  $-(CH_2)_nN[(1-4C)alkyl]_2$ ,  
 $-CH_2NHC(=O)CH_3$ ,  $-NHC(=O)NHR^{12}$ ,  $-NHC(=O)N[(1-4C)alkyl]_2$ ,



and the pharmaceutically acceptable salts thereof.

The present invention further provides a compound of Formula II:



wherein

5 X represents S or O;

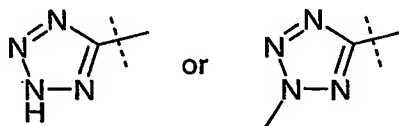
R¹ represents hydrogen, F, Cl, Br, I, CHO, -CN, -S(phenyl), CF₃, -(1-4C)alkyl, -(1-4C)alkoxy, -S(1-4C)alkyl, -SO(1-4C)alkyl, -SO₂(1-4C)alkyl, -C(=O)(1-3C)alkyl, NH₂, -NH(1-4C)alkyl, -N[(1-4C)alkyl]₂, or -NH(4-7C)cycloalkyl;

Z represents -O-(1-6C)alkyl, -O-(2-4C)alkenyl, -O-(1-6C)alkylaryl,

10 -O-(1-6C)alkyl(3-6C)cycloalkyl, -O-(1-6C)alkyl-N,N-(1-6C)dialkylamine, -O-(1-6C)alkyl-pyrrolidine, -O-(1-6C)alkyl-piperidine, -O-(1-6C)alkyl-morpholine, or NH(1-6C)alkyl;

R⁴ represents hydrogen, OH, -CH₂OH, -CH₂CH₂OH, -CH₂O(1-4C)alkyl, F, Cl, CF₃, OCF₃, -CN, NO₂, NH₂, -CH₂NH₂, -(1-4C)alkyl, -(1-4C)alkoxy, -C(=O)NH(1-4C)alkyl, -C(=O)NH₂, -CH₂C(=O)NH₂, -NHC(=O)(1-4C)alkyl, -(CH₂)ₘNHSO₂R¹⁰, -(CH₂)ₙCN, -CH₂NH₂, -C(=NOH)CH₃, -(CH₂)ₘCO₂(1-6C)alkyl, -C(=O)H, -C(=O)(1-4C)alkyl, -NH(1-4C)alkyl, -N[(1-4C)alkyl]₂, -SR¹⁰, -SOR¹⁰, -SO₂R¹⁰, SH, -CH₂SO₂NH₂,

-CH₂NHC(=O)CH₃,



20 R⁵ represents hydrogen, F, Cl, -CN, NO₂, NH₂, -(CH₂)ₘNHSO₂R¹⁰, -(1-4C)alkyl, or -(1-4C)alkoxy;

R⁶ represents hydrogen, -(1-4C)alkyl, -SO₂R¹¹, or -C(=O)(1-4C)alkyl;

R⁷ represents hydrogen or -(1-4C)alkyl;

R⁸ represents hydrogen, F, Cl, Br, -(1-4C)alkyl, -(1-4C)alkoxy, NO₂, NH₂, -CN,

-NHSO<sub>2</sub>R<sup>11</sup>, or -C(=O)(1-4C)alkyl;

R<sup>8a</sup> represents hydrogen, F, Cl, Br, -(1-4C)alkyl, NO<sub>2</sub>, NH<sub>2</sub>, NH(1-6C)alkyl,

N[(1-6C)alkyl]<sub>2</sub>, -C(=O)NH<sub>2</sub>, -CN, -CO<sub>2</sub>H, -S(1-4C)alkyl, -NHCO<sub>2</sub>(1-4C)alkyl,

-C(=O)NHCH<sub>2</sub>CH<sub>2</sub>CN, or -C(=O)(1-4C)alkyl;

- 5 R<sup>10</sup>, R<sup>11</sup>, and R<sup>12</sup> each independently represent -(1-4C)alkyl, -(CH<sub>2</sub>)<sub>3</sub>Cl, CF<sub>3</sub>, NH<sub>2</sub>, NH(1-4C)alkyl, N[(1-4C)alkyl]<sub>2</sub>, thienyl, phenyl, -CH<sub>2</sub>phenyl, or -(CH<sub>2</sub>)<sub>2</sub>phenyl, wherein phenyl, as used in substituent R<sup>10</sup>, R<sup>11</sup> or R<sup>12</sup>, is unsubstituted or substituted with F, Cl, Br, CF<sub>3</sub>, -(1-4C)alkyl, -(1-4)alkoxy, or acetyl;

R<sup>13</sup> represents hydrogen, -(1-4C)alkyl, -CH<sub>2</sub>CF<sub>3</sub>, triazole, or tetrazole;

- 10 R<sup>14</sup> represents -(1-4C)alkyl;

R<sup>15</sup> represents hydrogen or -(1-4C)alkyl;

m represents 0, 1, 2, or 3;

n represents 1, 2, 3, or 4;

p represents 1 or 2;

- 15 r represents 1 or 2; and

A is selected from the group consisting of -OH, Br, I, CF<sub>3</sub>, -(CH<sub>2</sub>)<sub>m</sub>CN, -C(CH<sub>3</sub>)<sub>2</sub>CN,

NO<sub>2</sub>, NH<sub>2</sub>, -O(CH<sub>2</sub>)<sub>n</sub>NH<sub>2</sub>, -O(CH<sub>2</sub>)<sub>n</sub>NHSO<sub>2</sub>(1-4C)alkyl, -O(CH<sub>2</sub>)<sub>n</sub>SO<sub>2</sub>(1-4C)alkyl,

-C(=O)NH(CH<sub>2</sub>)<sub>r</sub>NHSO<sub>2</sub>(1-4C)alkyl, -S(1-4C)alkyl,

-(1-6C)alkyl, -(1-4C)alkoxy, -(2-4C)alkenyl, -(2-4C)alkenyloxy, -CO<sub>2</sub>H,

- 20 -CO<sub>2</sub>(1-4C)alkyl, -CHO, -C(=O)(1-4C)alkyl, -C(=O)NH<sub>2</sub>, -C(=O)NH(1-6C)alkyl,

-C(=O)NR<sup>15</sup>(CH<sub>2</sub>)<sub>m</sub>phenyl wherein phenyl is unsubstituted or substituted with one or two substituents independently selected from the group consisting of OH, F, Cl, Br, I, NO<sub>2</sub>, NH<sub>2</sub>, -NHSO<sub>2</sub>(1-4C)alkyl, -CN, -(1-4C)alkyl, and -(1-4C)alkoxy; -OSO<sub>2</sub>CF<sub>3</sub>,

-O(CH<sub>2</sub>)<sub>n</sub>CN, -NHC(=O)(1-4C)alkyl, -NHC(=O)(CH<sub>2</sub>)<sub>m</sub>phenyl wherein phenyl is

- 25 unsubstituted or substituted with one or two substituents independently selected from the group consisting of OH, F, Cl, Br, I, NO<sub>2</sub>, NH<sub>2</sub>, CN, -(1-4C)alkyl and

-(1-4C)alkoxy; -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>12</sup>, -CH(CH<sub>3</sub>)(CH<sub>2</sub>)<sub>p</sub>NHSO<sub>2</sub>R<sup>12</sup>,

-(CH<sub>2</sub>)<sub>p</sub>CH(CH<sub>3</sub>)NHSO<sub>2</sub>R<sup>12</sup>, -NH(CH<sub>2</sub>)<sub>m</sub>phenyl wherein phenyl is unsubstituted or

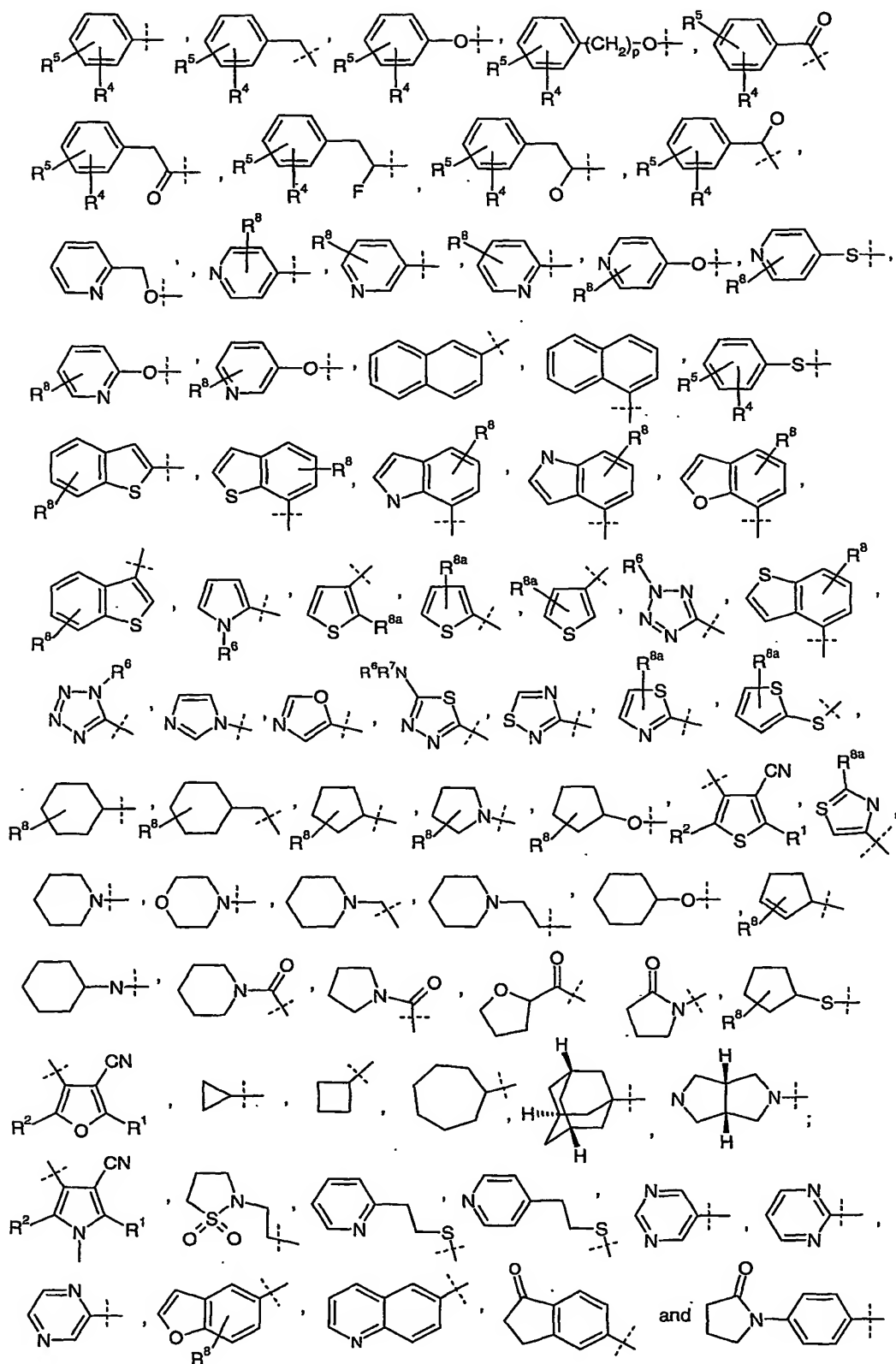
substituted with one or two substituents independently selected from the group consisting

- 30 of OH, F, Cl, Br, I, NO<sub>2</sub>, NH<sub>2</sub>, CN, -(1-4C)alkyl, and -(1-4C)alkoxy; -NH(1-4C)alkyl,

-N[(1-4C)alkyl]<sub>2</sub>, -C(=O)NH(3-6C)cycloalkyl, -C(=O)NH(CH<sub>2</sub>)<sub>n</sub>N[(1-4C)alkyl]<sub>2</sub>,

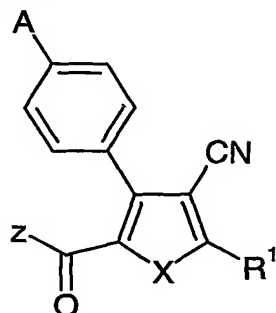
-C(=O)NH(CH<sub>2</sub>)<sub>n</sub>NH(1-4C)alkyl, -(CH<sub>2</sub>)<sub>n</sub>NH<sub>2</sub>, -O(CH<sub>2</sub>)<sub>n</sub>SR<sup>14</sup>, -O(CH<sub>2</sub>)<sub>n</sub>OR<sup>14</sup>,

$-(CH_2)_nNHR^{12}$ ,  $-(CH_2)_nNH(3-6C)cycloalkyl$ ,  $-(CH_2)_nN[(1-4C)alkyl]_2$ ,  
 $-CH_2NHC(=O)CH_3$ ,  $-NHC(=O)NHR^{12}$ ,  $-NHC(=O)N[(1-4C)alkyl]_2$ ,



and the pharmaceutically acceptable salts thereof.

In addition, the present invention provides compounds of Formula II':



Formula II'

wherein

5 X represents S or O;

R<sup>1</sup> represents hydrogen, F, Cl, Br, I, CHO, -CN, -S(phenyl), CF<sub>3</sub>, -(1-4C)alkyl, -(1-4C)alkoxy, -S(1-4C)alkyl, -SO(1-4C)alkyl, -SO<sub>2</sub>(1-4C)alkyl, -C(=O)(1-3C)alkyl, NH<sub>2</sub>, -NH(1-4C)alkyl, -N[(1-4C)alkyl]<sub>2</sub>, or -NH(4-7C)cycloalkyl;

Z represents -O-(1-6C)alkyl, -O-(2-4C)alkenyl, -O-(1-6C)alkylaryl, -O-(1-6C)alkyl(3-6C)cycloalkyl, -O-(1-6C)alkyl-N,N-(1-6C)dialkylamine, -O-(1-6C)alkyl-pyrrolidine, -O-(1-6C)alkyl-piperidine, -O-(1-6C)alkyl-morpholine, or NH(1-6C)alkyl;

R<sup>4</sup> represents hydrogen, OH, -CH<sub>2</sub>OH, -CH<sub>2</sub>O(1-4C)alkyl, F, Cl, CF<sub>3</sub>, OCF<sub>3</sub>, -CN, NO<sub>2</sub>, NH<sub>2</sub>, -(1-4C)alkyl, -(1-4C)alkoxy, -C(=O)NH(1-4C)alkyl, -NHC(=O)(1-4C)alkyl, 15 -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>10</sup>, -(CH<sub>2</sub>)<sub>n</sub>CN, -(CH<sub>2</sub>)<sub>m</sub>CO<sub>2</sub>H, -(CH<sub>2</sub>)<sub>m</sub>CO<sub>2</sub>(1-6C)alkyl, -C(=O)H, -C(=O)(1-4C)alkyl, -NH(1-4C)alkyl, -N[(1-4C)alkyl]<sub>2</sub>, -SR<sup>10</sup>, -SOR<sup>10</sup>, -SO<sub>2</sub>R<sup>10</sup>, SH, phenyl, or phenyl substituted with one or two substituents independently selected from the group consisting of F, Cl, Br, I, -CN, -(1-4C)alkyl, and -(1-4C)alkoxy;

R<sup>5</sup> represents hydrogen; F, Cl, -CN, NO<sub>2</sub>, NH<sub>2</sub>, -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>10</sup>, -(1-4C)alkyl, or (1-4C)alkoxy;

R<sup>6</sup> represents hydrogen, -(1-4C)alkyl, -SO<sub>2</sub>R<sup>11</sup>, or C(=O)(1-4C)alkyl;

R<sup>7</sup> represents hydrogen or -(1-4C)alkyl;

R<sup>8</sup> represents hydrogen, F, Cl, Br, -(1-4C)alkyl, NO<sub>2</sub>, NH<sub>2</sub>, -CN, -NHSO<sub>2</sub>R<sup>11</sup>, or -C(=O)(1-4C)alkyl;

25 R<sup>8a</sup> represents hydrogen, F, Cl, Br, -(1-4C)alkyl, NO<sub>2</sub>, NH<sub>2</sub>, -CN, -S(1-4C)alkyl, or -C(=O)(1-4C)alkyl;

$R^{10}$ ,  $R^{11}$ , and  $R^{12}$  each independently represent  $-(1-4C)alkyl$ ,  $phenyl$ ,  $-CH_2phenyl$ , or  $-(CH_2)_2phenyl$ , wherein  $phenyl$ , as used in substituent  $R^9$ ,  $R^{10}$ ,  $R^{11}$  or  $R^{12}$ , is unsubstituted or substituted with  $F$ ,  $Cl$ ,  $Br$ ,  $CF_3$ ,  $-(1-4C)alkyl$ , or  $-(1-4)alkoxy$ ;

$R^{15}$  represents hydrogen or  $-(1-4C)alkyl$ ;

5  $m$  represents 0, 1, 2, or 3;

$n$  represents 1, 2, 3, or 4;

$p$  represents 1 or 2; and

$A$  is selected from the group consisting of  $I$ ,  $-(CH_2)_mCN$ ,  $NO_2$ ,  $NH_2$ ,

$-(1-6C)alkyl$ ,  $-(1-4C)alkoxy$ ,  $-(2-4C)alkenyl$ ,  $-(2-4C)alkenyloxy$ ,  $-CO_2H$ ,

10  $-CO_2(1-4C)alkyl$ ,  $-CHO$ ,  $-C(=O)(1-4C)alkyl$ ,  $-C(=O)NH_2$ ,  $-C(=O)NH(1-6C)alkyl$ ,

$-C(=O)NR^{15}(CH_2)_mphenyl$  wherein  $phenyl$  is unsubstituted or substituted with one or two

substituents independently selected from the group consisting of  $OH$ ,  $F$ ,  $Cl$ ,  $Br$ ,  $I$ ,  $NO_2$ ,

$NH_2$ ,  $-NHSO_2(1-4C)alkyl$ ,  $-CN$ ,  $-(1-4C)alkyl$  and  $-(1-4C)alkoxy$ ;  $-OSO_2CF_3$ ,

$-O(CH_2)_nCN$ ,  $-NHC(=O)(1-4C)alkyl$ ,  $-NHC(=O)(CH_2)_mphenyl$  wherein  $phenyl$  is

15 unsubstituted or substituted with one or two substituents independently selected from the group consisting of  $OH$ ,  $F$ ,  $Cl$ ,  $Br$ ,  $I$ ,  $NO_2$ ,  $NH_2$ ,  $-CN$ ,  $-(1-4C)alkyl$  and

$-(1-4C)alkoxy$ ;  $-(CH_2)_mNHSO_2R^{12}$ ,  $-CH(CH_3)(CH_2)_pNHSO_2R^{12}$ ,

$-(CH_2)_pCH(CH_3)NHSO_2R^{12}$ ,  $-NH(CH_2)_mphenyl$  wherein  $phenyl$  is unsubstituted or

substituted with one or two substituents independently selected from the group consisting

20 of  $OH$ ,  $F$ ,  $Cl$ ,  $Br$ ,  $I$ ,  $NO_2$ ,  $NH_2$ ,  $-CN$ ,  $-(1-4C)alkyl$ , and  $-(1-4C)alkoxy$ ;  $-NH(1-4C)alkyl$ ,

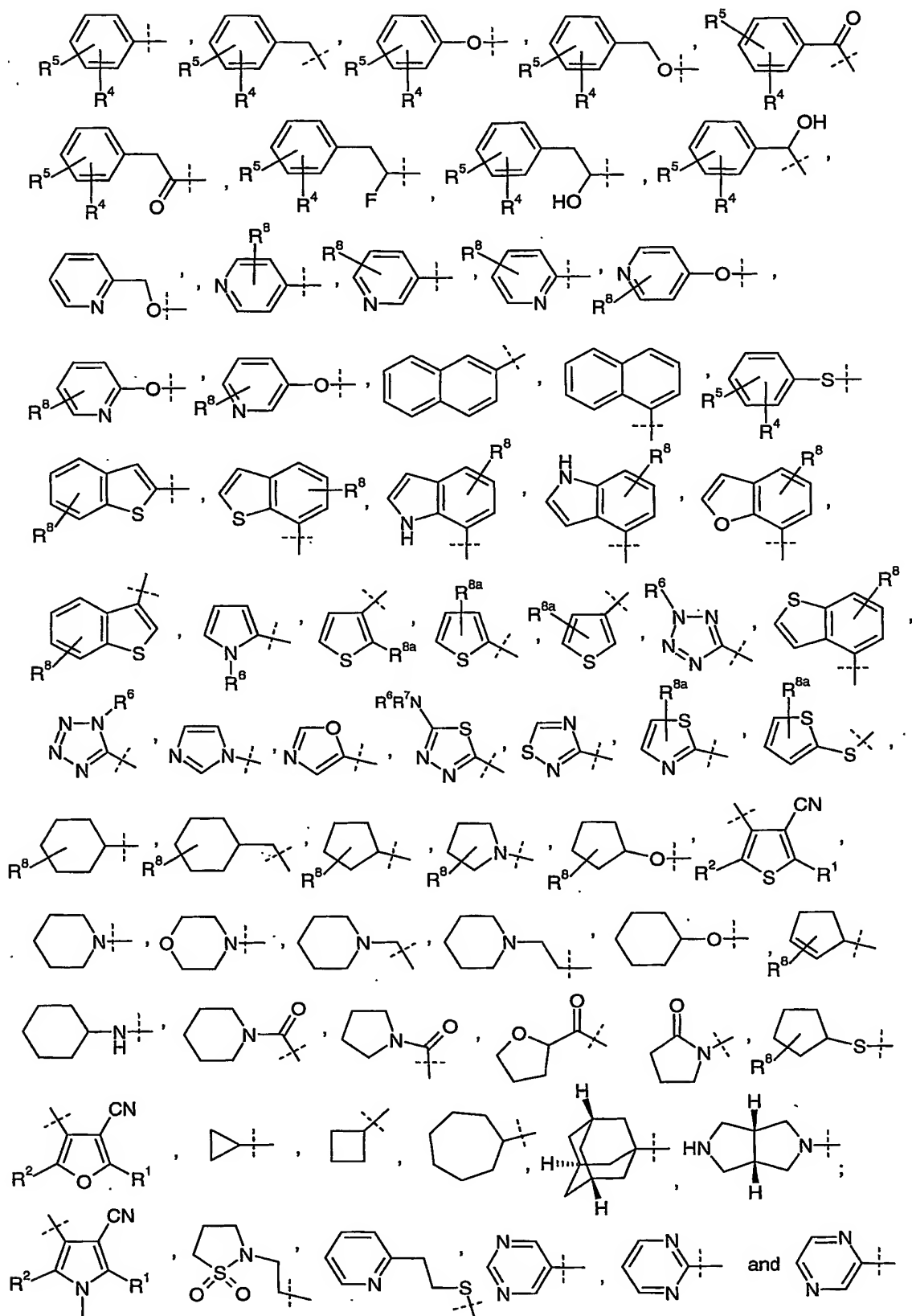
$-N[(1-4C)alkyl]_2$ ,  $-C(=O)NH(3-6C)cycloalkyl$ ,  $-C(=O)NH(CH_2)_nN[(1-4C)alkyl]_2$ ,

$-C(=O)NH(CH_2)_nNH(1-4C)alkyl$ ,  $-(CH_2)_nNH_2$ ,  $-O(CH_2)_nSR^{14}$ ,  $-O(CH_2)_nOR^{14}$ ,

$-(CH_2)_nNHR^{12}$ ,  $-(CH_2)_nNH(3-6C)cycloalkyl$ ,  $-(CH_2)_nN[(1-4C)alkyl]_2$ ,  $-NHC(=O)NHR^{12}$ ,

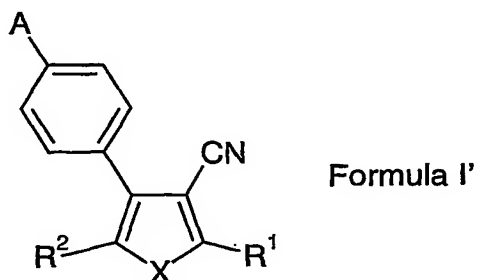
$-NHC(=O)N[(1-4C)alkyl]_2$ .





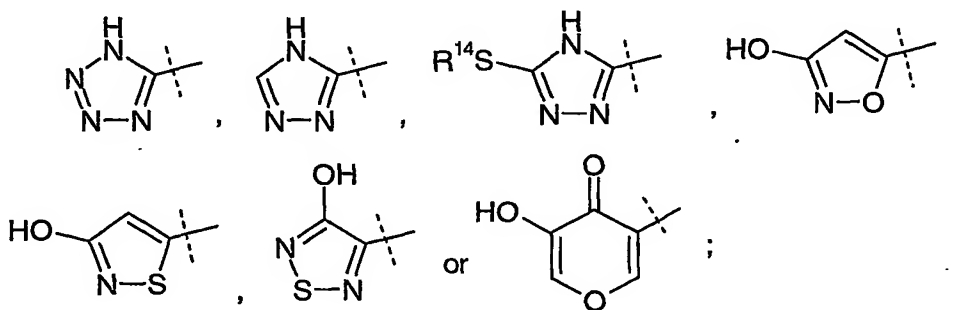
and the pharmaceutically acceptable salts thereof.

The present invention further provides compounds of Formula I':



wherein

- 5 X represents S or O;
- $R^1$  represents hydrogen, F, Cl, Br, I, CHO, -CN, -S(phenyl),  $CF_3$ , -(1-4C)alkyl, -(1-4C)alkoxy, -S(1-4C)alkyl, -SO(1-4C)alkyl, -SO<sub>2</sub>(1-4C)alkyl, -C(=O)(1-3C)alkyl, NH<sub>2</sub>, -NH(1-4C)alkyl, -N[(1-4C)alkyl]<sub>2</sub>, -NH(4-7C)cycloalkyl, or -N[(1-4C)alkyl](CH<sub>2</sub>)<sub>r</sub>N[(1-4C)alkyl]<sub>2</sub>;
- 10  $R^2$  represents -CN, -CO<sub>2</sub>H, -C(=O)NHR<sup>13</sup>, -C(=O)NHOH, -C(=O)NHCN, -SO<sub>2</sub>OH, -SO<sub>2</sub>NH(1-4C)alkyl, -C(=O)NHSO<sub>2</sub>(1-4C)alkyl, -PH(=O)(OH), -P(=O)(OH)<sub>2</sub>, -P(=O)(OH)NH<sub>2</sub>, -P(=O)(OH)CH[(1-4C)alkoxy]<sub>2</sub>, -C(=O)NHSO<sub>2</sub>CF<sub>3</sub>, -C(=O)NHSO<sub>2</sub>CH<sub>2</sub>CF<sub>3</sub>,



- 15  $R^4$  represents hydrogen, OH, -CH<sub>2</sub>OH, -CH<sub>2</sub>O(1-4C)alkyl, F, Cl,  $CF_3$ , OCF<sub>3</sub>, -CN, NO<sub>2</sub>, NH<sub>2</sub>, -(1-4C)alkyl, -(1-4C)alkoxy, -C(=O)NH(1-4C)alkyl, -C(=O)NH<sub>2</sub>, -NHC(=O)(1-4C)alkyl, -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>10</sup>, -(CH<sub>2</sub>)<sub>n</sub>CN, -(CH<sub>2</sub>)<sub>m</sub>CO<sub>2</sub>H, -(CH<sub>2</sub>)<sub>m</sub>CO<sub>2</sub>(1-6C)alkyl, -C(=O)H, -C(=O)(1-4C)alkyl, -NH(1-4C)alkyl, -N[(1-4C)alkyl]<sub>2</sub>, -SR<sup>10</sup>, -SOR<sup>10</sup>, -SO<sub>2</sub>R<sup>10</sup>, SH, phenyl, or phenyl substituted with one or two substituents
- 20 independently selected from the group consisting of F, Cl, Br, I, -CN, -(1-4C)alkyl, and -(1-4C)alkoxy;
- $R^5$  represents hydrogen; F, Cl, -CN, NO<sub>2</sub>, NH<sub>2</sub>, -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>10</sup>, -(1-4C)alkyl, or

-(1-4C)alkoxy;

R<sup>6</sup> represents hydrogen, -(1-4C)alkyl, -SO<sub>2</sub>R<sup>11</sup>, or -C(=O)(1-4C)alkyl;

R<sup>7</sup> represents hydrogen or -(1-4C)alkyl;

R<sup>8</sup> represents hydrogen, F, Cl, Br, -(1-4C)alkyl, -(1-4C)alkoxy, NO<sub>2</sub>, NH<sub>2</sub>, -CN,

5 -NHSO<sub>2</sub>R<sup>11</sup>, or -C(=O)(1-4C)alkyl;

R<sup>8a</sup> represents hydrogen, F, Cl, Br, -(1-4C)alkyl, NO<sub>2</sub>, NH<sub>2</sub>, NH(1-6C)alkyl,

N[(1-6C)alkyl]<sub>2</sub>, -C(=O)NH<sub>2</sub>, -CN, -CO<sub>2</sub>H, -S(1-4C)alkyl, -NHCO<sub>2</sub>(1-4C)alkyl, or

-C(=O)(1-4C)alkyl;

R<sup>10</sup>, R<sup>11</sup>, and R<sup>12</sup> each independently represent -(1-4C)alkyl, -(CH<sub>2</sub>)<sub>3</sub>Cl, phenyl,

10 -CH<sub>2</sub>phenyl, or -(CH<sub>2</sub>)<sub>2</sub>phenyl, wherein phenyl, as used in substituent R<sup>10</sup>, R<sup>11</sup> or R<sup>12</sup>, is unsubstituted or substituted with F, Cl, Br, CF<sub>3</sub>, -(1-4C)alkyl, or -(1-4)alkoxy;

R<sup>13</sup> represents hydrogen, -(1-4C)alkyl, -CH<sub>2</sub>CF<sub>3</sub>, triazole, or tetrazole;

R<sup>14</sup> represents -(1-4C)alkyl;

R<sup>15</sup> represents hydrogen or -(1-4C)alkyl;

15 m represents 0, 1, 2, or 3;

n represents 1, 2, 3, or 4;

p represents 1 or 2;

r represents 1 or 2; and

A is selected from the group consisting of -OH, Br, I, -(CH<sub>2</sub>)<sub>m</sub>CN, -C(CH<sub>3</sub>)<sub>2</sub>CN, NO<sub>2</sub>,

20 NH<sub>2</sub>, -O(CH<sub>2</sub>)<sub>n</sub>NH<sub>2</sub>, -O(CH<sub>2</sub>)<sub>n</sub>NHSO<sub>2</sub>(1-4C)alkyl, -O(CH<sub>2</sub>)<sub>n</sub>SO<sub>2</sub>(1-4C)alkyl,

-C(=O)NH(CH<sub>2</sub>)<sub>r</sub>NHSO<sub>2</sub>(1-4C)alkyl, -S(1-4C)alkyl,

-(1-6C)alkyl, -(1-4C)alkoxy, -(2-4C)alkenyl, -(2-4C)alkenyloxy, -CO<sub>2</sub>H,

-CO<sub>2</sub>(1-4C)alkyl, -CHO, -C(=O)(1-4C)alkyl, -C(=O)NH<sub>2</sub>, -C(=O)NH(1-6C)alkyl,

-C(=O)NR<sup>15</sup>(CH<sub>2</sub>)<sub>m</sub>phenyl wherein phenyl is unsubstituted or substituted with one or two

25 substituents independently selected from the group consisting of OH, F, Cl, Br, I, NO<sub>2</sub>,

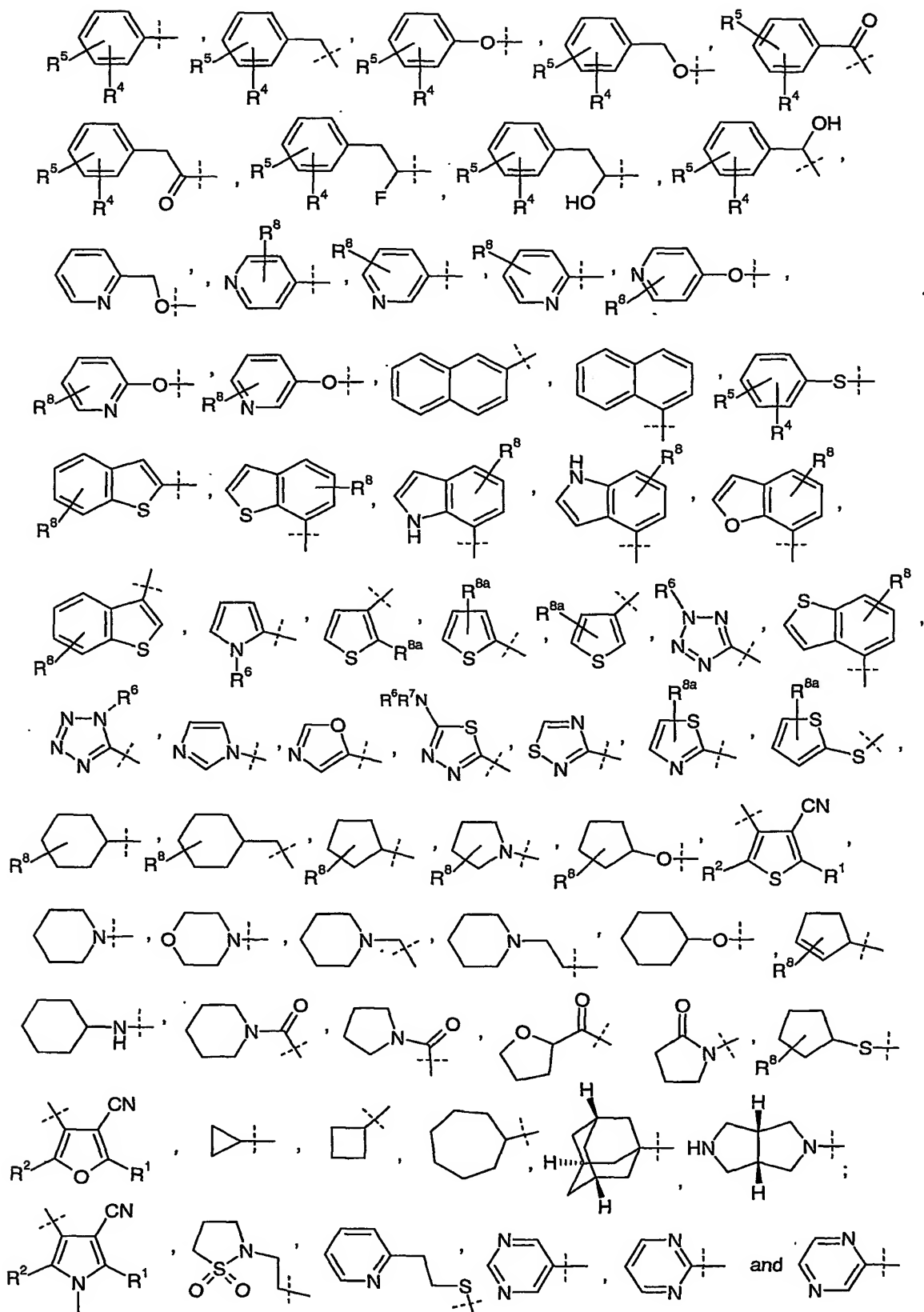
NH<sub>2</sub>, -NHSO<sub>2</sub>(1-4C)alkyl, -CN, -(1-4C)alkyl, and -(1-4C)alkoxy; -OSO<sub>2</sub>CF<sub>3</sub>,

-O(CH<sub>2</sub>)<sub>n</sub>CN, -NHC(=O)(1-4C)alkyl, -NHC(=O)(CH<sub>2</sub>)<sub>m</sub>phenyl wherein phenyl is

unsubstituted or substituted with one or two substituents independently selected from the group consisting of OH, F, Cl, Br, I, NO<sub>2</sub>, NH<sub>2</sub>, CN, -(1-4C)alkyl and

30 -(1-4C)alkoxy; -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>12</sup>, -CH(CH<sub>3</sub>)(CH<sub>2</sub>)<sub>p</sub>NHSO<sub>2</sub>R<sup>12</sup>,

5  $-(\text{CH}_2)_p\text{CH}(\text{CH}_3)\text{NHSO}_2\text{R}^{12}$ ,  $-\text{NH}(\text{CH}_2)_m\text{phenyl}$  wherein phenyl is unsubstituted or substituted with one or two substituents independently selected from the group consisting of OH, F, Cl, Br, I,  $\text{NO}_2$ ,  $\text{NH}_2$ , CN,  $-(1-4\text{C})\text{alkyl}$ , and  $-(1-4\text{C})\text{alkoxy}$ ;  $-\text{NH}(1-4\text{C})\text{alkyl}$ ,  $-\text{N}[(1-4\text{C})\text{alkyl}]_2$ ,  $-\text{C}(=\text{O})\text{NH}(3-6\text{C})\text{cycloalkyl}$ ,  $-\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n\text{N}[(1-4\text{C})\text{alkyl}]_2$ ,  $-\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n\text{NH}(1-4\text{C})\text{alkyl}$ ,  $-(\text{CH}_2)_n\text{NH}_2$ ,  $-\text{O}(\text{CH}_2)_n\text{SR}^{14}$ ,  $-\text{O}(\text{CH}_2)_n\text{OR}^{14}$ ,  $-(\text{CH}_2)_n\text{NHR}^{12}$ ,  $-(\text{CH}_2)_n\text{NH}(3-6\text{C})\text{cycloalkyl}$ ,  $-(\text{CH}_2)_n\text{N}[(1-4\text{C})\text{alkyl}]_2$ ,  $-\text{NHC}(=\text{O})\text{NHR}^{12}$ ,  $-\text{NHC}(=\text{O})\text{N}[(1-4\text{C})\text{alkyl}]_2$ ,



and the pharmaceutically acceptable salts thereof.

It is appreciated by one of ordinary skill in the art that compounds of Formula II encompass both useful intermediates for the preparation of compounds of Formula I and also prodrugs of Formula I.

5       The present invention further provides a method of potentiating glutamate receptor function in a patient, which comprises administering to said patient an effective amount of a compound of Formula I.

10       In addition, the present invention further provides a method of treating schizophrenia, cognitive deficits associated with schizophrenia, Alzheimer's disease, dementia of the Alzheimer's type, mild cognitive impairment, Parkinson's disease, or depression, in a patient, which comprises administering to said patient an effective amount of a compound of Formula I or Formula II.

15       According to another aspect, the present invention provides the use of a compound of Formula I or Formula II, or a pharmaceutically acceptable salt thereof, for the manufacture of a medicament for treating schizophrenia, cognitive deficits associated with schizophrenia, Alzheimer's disease, dementia of the Alzheimer's type, mild cognitive impairment, Parkinson's disease, or depression.

20       In addition, the present invention provides the use of a compound of Formula I or Formula II, or a pharmaceutically acceptable salt thereof, for treating schizophrenia, cognitive deficits associated with schizophrenia, Alzheimer's disease, dementia of the Alzheimer's type, mild cognitive impairment, Parkinson's disease, or depression.

25       The invention further provides pharmaceutical compositions comprising, a compound of Formula I, or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier, diluent, or excipient.

30       The invention further provides pharmaceutical compositions comprising, a compound of Formula II, or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable diluent or carrier.

30       This invention also encompasses novel intermediates used in the preparation of compounds of Formula I and Formula II, prodrugs of the compounds of Formula I, and processes for the synthesis of the compounds of Formula I and Formula II.

      In addition, the present invention provides a pharmaceutical composition which comprises a first component which is a compound of Formula I or Formula II, or a

pharmaceutically acceptable salt thereof, and a second component which is an antipsychotic.

The present invention provides a pharmaceutical composition which comprises a first component which is a compound of Formula I or Formula II, or a pharmaceutically acceptable salt thereof, and a second component which is an antidepressant.

In addition, the present invention provides a pharmaceutical composition which comprises a first component which is a compound of Formula I or Formula II, or a pharmaceutically acceptable salt thereof, and a second component which is a drug useful in treating a cognitive disorder.

The invention further provides a method for treating a patient suffering from or susceptible to schizophrenia or cognitive deficits associated with schizophrenia comprising administering to said patient an effective amount of a first component which is a compound of Formula I or Formula II, or a pharmaceutically acceptable salt thereof, in combination with an effective amount of a second component which is an antipsychotic.

The invention further provides a method for treating a patient suffering from or susceptible to depression, comprising administering to said patient an effective amount of a first component which is a compound of Formula I or Formula II, or a pharmaceutically acceptable salt thereof, in combination with an effective amount of a second component which is an antidepressant.

The invention further provides a method for treating a patient suffering from or susceptible to a cognitive disorder, comprising administering to said patient an effective amount of a first component which is a compound of Formula I or Formula II, or a pharmaceutically acceptable salt thereof, in combination with an effective amount of a second component which is a drug useful in treating a cognitive disorder.

### **DETAILED DESCRIPTION OF THE INVENTION**

As used herein the term "potentiating glutamate receptor function" refers to any increased responsiveness of glutamate receptors, for example AMPA receptors, to glutamate or an agonist, and includes but is not limited to inhibition of rapid desensitization or deactivation of AMPA receptors to glutamate.

A wide variety of conditions may be treated or prevented by compounds of Formula I or Formula II, and their pharmaceutically acceptable salts through their action as potentiators of glutamate receptor function. Such conditions include those associated with glutamate hypofunction, such as psychiatric and neurological disorders, for example cognitive disorders and neuro-degenerative disorders such as Alzheimer's disease; dementia of the Alzheimer's type, age-related dementias; age-induced memory impairment; cognitive deficits due to autism, Down's syndrome and other central nervous system disorders with childhood onset, cognitive deficits post electroconvulsive therapy, movement disorders such as tardive dyskinesia, Huntington's chorea, myoclonus, dystonia, spasticity, Parkinson's disease; reversal of drug-induced states (such as cocaine, amphetamines, alcohol-induced states); depression, including major depressive disorder and treatment resistant depression; attention deficit disorder; attention deficit hyperactivity disorder; psychosis such as schizophrenia; cognitive deficits associated with psychosis such as schizophrenia, drug-induced psychosis, stroke, and sexual dysfunction. Compounds of Formula I or Formula II may also be useful for improving memory (both short term and long term) and learning ability. The present invention provides the use of compounds of Formula I or Formula II for the treatment of each of these conditions.

It is understood by one of ordinary skill in the art that cognition includes various "domains". These domains include short-term memory, long term memory, working memory, executive function, and attention. As used herein the term "cognitive disorder" is meant to encompass any disorder characterized by a deficit in one or more of the cognitive domains, including but not limited to short term memory, long term memory, working memory, executive function, and attention. It is further understood that the term "cognitive disorder" includes, but is not limited to the following specific disorders: age-related cognitive decline, mild cognitive impairment, Alzheimer's disease, dementia, dementia of the Alzheimer's type, Parkinson's dementia, Lewy Body dementia, substance-induced persisting dementia, alcohol-induced persisting dementia, alcohol-induced cognitive impairment, AIDS-induced dementia, learning disorders, cognitive deficits subsequent to cardiac bypass surgery and grafting, stroke, cerebral ischemia, spinal cord trauma, head trauma, perinatal hypoxia, cardiac arrest, and hypoglycemic neuronal damage, vascular dementia, multi-infarct dementia, cognitive deficits associated



with amyotrophic lateral sclerosis, and cognitive deficits associated with multiple sclerosis.

The fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (1994, American Psychiatric Association, Washington, D.C.) provides a  
5 diagnostic tool for identifying many of the disorders described herein. The skilled artisan will recognize that there are alternative nomenclatures, nosologies, and classification systems for disorders described herein, including those as described in the DMS-IV and that terminology and classification systems evolve with medical scientific progress.

As used herein the term "a drug useful in treating a cognitive disorder" includes,  
10 but is not limited to acetylcholinesterase inhibitors, NMDA receptor antagonists, 5-HT<sub>6</sub> antagonists, M1 agonists, serotonin reuptake inhibitors, norepinephrine reuptake inhibitors, selective norepinephrine reuptake inhibitors, combined serotonin-norepinephrine reuptake inhibitors, monoamine oxidase inhibitors, phosphodiesterase-4 inhibitors, tricyclic antidepressants, and AMPA receptor potentiators. More specifically,  
15 the term "a drug useful in treating a cognitive disorder" includes, but is not limited to the following compounds which are well known and readily available to one of ordinary skill in the art: donepezil, rivastigmine, galantamine, memantine, tacrine, phenserine, physostigmine, xanomeline, CX516, milameline, aniracetam, piracetam, oxiracetam, suritazole, fluoxetine, sertraline, citalopram, duloxetine, atomoxetine, venlafaxine,  
20 milnacipran, fluvoxamine, paroxetine, bupropion, reboxetine, imipramine, and rolipram.

As used herein the term "antidepressant" includes serotonin reuptake inhibitors, norepinephrine-serotonin reuptake inhibitors, selective norepinephrine reuptake inhibitors, and the like. For example, "antidepressant" includes fluoxetine, venlafaxine, citalopram, fluvoxamine, paroxetine, sertraline, milnacipran and duloxetine. Fluoxetine  
25 and duloxetine are preferred antidepressants.

As used herein the term "antipsychotic" includes typical and atypical antipsychotics. Thus, the term "antipsychotic" includes, for example, haloperidol, chlorpromazine, clozapine, risperidone, olanzapine, aripiprazole, ziprasidone, sertindole, amisulpride, zotepine, sulpiride, and quetiapine. Olanzapine is the preferred  
30 antipsychotic.

As used herein "fluoxetine" will be used to mean any acid addition salt or the free base, and to include either the racemic mixture or either of the R and S enantiomers.

Fluoxetine hydrochloride is a preferred salt.

The following specific combinations are preferred:

- 5                    Formula I/fluoxetine
- Formula I/duloxetine
- Formula I/paroxetine
- Formula I/olanzapine
- Formula I/risperidone
- 10                  Formula I/aripiprazole
- Formula I/ sertindole
- Formula I/ quetiapine
- Formula I/ ziprasidone
- Formula I/zotepine
- 15                  Formula I/memantine
- Formula I/ donepezil
- Formula I/rivastigmine
- Formula I/galantamine,
- Formula I/ tacrine
- 20                  Formula I/CX516
- Formula I/atomoxetine
- Formula II/fluoxetine
- Formula II/duloxetine
- Formula II/paroxetine
- 25                  Formula II/olanzapine
- Formula II/risperidone
- Formula II/aripiprazole
- Formula II/ sertindole
- Formula II/ quetiapine
- 30                  Formula II/ ziprasidone
- Formula II/zotepine
- Formula II/memantine

Formula II/ donepezil

Formula II/rivastigmine

Formula II/galantamine,

Formula II/ tacrine

5 Formula II/CX516

Formula II/atomoxetine

The present invention includes the pharmaceutically acceptable salts of the compounds defined by Formula I and Formula II. A compound of this invention can  
10 possess a sufficiently acidic group, a sufficiently basic group, or both functional groups, and accordingly react with any of a number of organic and inorganic bases, and inorganic and organic acids, to form a pharmaceutically acceptable salt.

The term "pharmaceutically acceptable salt" as used herein, refers to salts of the compounds of the above Formulas which are substantially non-toxic to living organisms.  
15 Typical pharmaceutically acceptable salts include those salts prepared by reaction of the compounds of the present invention with a pharmaceutically acceptable mineral or organic acid or an organic or inorganic base. Such salts are known as acid addition and base addition salts. Such salts include the pharmaceutically acceptable salts listed in Journal of Pharmaceutical Science, 66, 2-19 (1977), which are known to the skilled  
20 artisan. Acids commonly employed to form acid addition salts are inorganic acids such as hydrochloric acid, hydrobromic acid, hydroiodic acid, sulfuric acid, phosphoric acid, and the like, and organic acids such as *p*-toluenesulfonic, methanesulfonic acid, benzenesulfonic acid, oxalic acid, *p*-bromophenylsulfonic acid, carbonic acid, succinic acid, citric acid, benzoic acid, acetic acid, and the like. Examples of such  
25 pharmaceutically acceptable salts are the sulfate, pyrosulfate, bisulfate, sulfite, bisulfite, phosphate, monohydrogenphosphate, dihydrogenphosphate, metaphosphate, pyrophosphate, bromide, iodide, acetate, propionate, decanoate, caprate, caprylate, acrylate, ascorbate, formate, hydrochloride, dihydrochloride, isobutyrate, caproate, heptanoate, propiolate, propionate, phenylpropionate, salicylate, oxalate, malonate,  
30 succinate, suberate, sebacate, fumarate, malate, maleate, hydroxymaleate, mandelate, nicotinate, isonicotinate, cinnamate, hippurate, nitrate, phthalate, teraphthalate, butyne-1,4-dioate, butyne-1,4-dicarboxylate, hexyne-1,4-dicarboxylate, hexyne-1,6-dioate,

benzoate, chlorobenzoate, methylbenzoate, hydroxybenzoate, methoxybenzoate, dinitrobenzoate, *o*-acetoxybenzoate, naphthalene-2-benzoate, phthalate, *p*-toluenesulfonate, *p*-bromobenzenesulfonate, *p*-chlorobenzenesulfonate, xylenesulfonate, phenylacetate, trifluoroacetate, phenylpropionate, phenylbutyrate, citrate, lactate,  $\alpha$ -hydroxybutyrate, glycolate, tartrate, benzenesulfonate, methanesulfonate, ethanesulfonate, 5 propanesulfonate, hydroxyethanesulfonate, 1-naphthalenesulfonate, 2-naphthalenesulfonate, 1,5-naphthalenedisulfonate, mandelate, tartarate, and the like. Preferred pharmaceutically acceptable acid addition salts are those formed with mineral acids such as hydrochloric acid and hydrobromic acid, and those formed with organic 10 acids such as maleic acid, oxalic acid and methanesulfonic acid. The HCl salt is most preferred.

Base addition salts include those derived from inorganic bases, such as ammonium or alkali or alkaline earth metal hydroxides, carbonates, bicarbonates, and the like. Such bases useful in preparing the salts of this invention thus include sodium hydroxide, 15 potassium hydroxide, ammonium hydroxide, potassium carbonate, sodium carbonate, sodium bicarbonate, potassium bicarbonate, calcium hydroxide, calcium carbonate, and the like. The potassium and sodium salt forms are particularly preferred.

It should be recognized that the particular counterion forming a part of any salt of this invention is usually not of a critical nature, so long as the salt as a whole is 20 pharmacologically acceptable and as long as the counterion does not contribute undesired qualities to the salt as a whole. It is further understood that the above salts may form hydrates or exist in a substantially anhydrous form.

As used herein the term "prodrug" refers to compounds that are drug precursors, which following administration, release the drug *in vivo* via a chemical or physiological 25 process. For example, a prodrug, on being brought to the physiological pH or through enzyme action, is converted to the desired drug form *in vivo* by enzymatic and/or chemical hydrolytic cleavage of an ester to provide the corresponding carboxylic acid drug.

Various forms of prodrugs are known to one of ordinary skill in the art. For 30 examples of such prodrug derivatives, see *Design of Prodrugs*, edited by H. Bundgaard, (Elsevier, 1985); D. Fleisher, et al., *Advanced Drug Delivery Reviews*, 19, 115, (1996); H. Bundgaard, *Advanced Drug Delivery Reviews*, 8, 1-38 (1992); H. Bundgaard, et al.,

*Journal of Pharmaceutical Sciences*, 77, 285 (1988); and N. Kakeya, et al., *Chem Pharm Bull*, 32, 692 (1984).

Examples of prodrugs of Formula I are those that form *in vivo* cleavable esters or amides. An *in vivo* cleavable ester or amide is, for example, an ester or amide which is  
5 cleaved in the human or animal body to produce the parent acid of Formula Ia. The amide and ester moieties may incorporate other functional groups including but not limited to ether, amine and carboxylic acid functionalities. Free hydroxy groups may be derivatized using groups including but not limited to hemisuccinates, phosphate esters, dimethylaminoacetates, and phosphoryloxymethyloxycarbonyls, as outlined in D.  
10 Fleisher, R. Bong, B. H. Stewart, *Advanced Drug Delivery Reviews* (1996) 19, 115. Carbamate prodrugs of hydroxy and amino groups are also included, as are carbonate prodrugs and sulfate esters of hydroxy groups. Derivatization of hydroxy groups as (acyloxy)methyl and (acyloxy)ethyl ethers wherein the acyl group may be an alkyl ester, optionally substituted with groups including but not limited to ether, amine and carboxylic  
15 acid functionalities, or where the acyl group is an amino acid ester as described above, are also encompassed. Prodrugs of this type are described in R. P. Robinson et al., *J. Medicinal Chemistry* (1996) 39, 10.

As used herein, the term "stereoisomer" refers to a compound made up of the same atoms bonded by the same bonds but having different three-dimensional structures which  
20 are not interchangeable. The three-dimensional structures are called configurations. As used herein, the term "enantiomer" refers to two stereoisomers whose molecules are nonsuperimposable mirror images of one another. The term "chiral center" refers to a carbon atom to which four different groups are attached. As used herein, the term "diastereomers" refers to stereoisomers which are not enantiomers. In addition, two  
25 diastereomers which have a different configuration at only one chiral center are referred to herein as "epimers". The terms "racemate", "racemic mixture" or "racemic modification" refer to a mixture of equal parts of enantiomers.

The term "enantiomeric enrichment" as used herein refers to the increase in the amount of one enantiomer as compared to the other.

A convenient method of expressing the enantiomeric enrichment achieved is the concept of enantiomeric excess, or "ee", which is found using the following equation:

$$ee = \frac{E^1 - E^2}{E^1 + E^2} \times 100$$

5 wherein  $E^1$  is the amount of the first enantiomer and  $E^2$  is the amount of the second enantiomer. Thus, if the initial ratio of the two enantiomers is 50:50, such as is present in a racemic mixture, and an enantiomeric enrichment sufficient to produce a final ratio of 50:30 is achieved, the ee with respect to the first enantiomer is 25%. However, if the final  
10 ratio is 90:10, the ee with respect to the first enantiomer is 80%. An ee of greater than 90% is preferred, an ee of greater than 95% is most preferred and an ee of greater than 99% is most especially preferred. Enantiomeric enrichment is readily determined by one of ordinary skill in the art using standard techniques and procedures, such as gas or high performance liquid chromatography with a chiral column. Choice of the appropriate  
15 chiral column, eluent and conditions necessary to effect separation of the enantiomeric pair is well within the knowledge of one of ordinary skill in the art. In addition, the specific stereoisomers and enantiomers of compounds of Formula I and Formula II can be prepared by one of ordinary skill in the art utilizing well known techniques and processes, such as those disclosed by J. Jacques, et al., "Enantiomers, Racemates, and Resolutions", John Wiley and Sons, Inc., 1981, and E.L. Eliel and S.H. Wilen, "Stereochemistry of  
20 Organic Compounds", (Wiley-Interscience 1994), and European Patent Application No. EP-A-838448, published April 29, 1998. Examples of resolutions include recrystallization techniques or chiral chromatography.

Some of the compounds of the present invention have one or more chiral centers and may exist in a variety of stereoisomeric configurations. As a consequence of these  
25 chiral centers, the compounds of the present invention occur as racemates, mixtures of enantiomers and as individual enantiomers, as well as diastereomers and mixtures of diastereomers. All such racemates, enantiomers, and diastereomers are within the scope of the present invention.

The terms "R" and "S" are used herein as commonly used in organic chemistry to  
30 denote specific configuration of a chiral center. The term "R" (rectus) refers to that configuration of a chiral center with a clockwise relationship of group priorities (highest to second lowest) when viewed along the bond toward the lowest priority group. The term "S" (sinister) refers to that configuration of a chiral center with a counterclockwise

relationship of group priorities (highest to second lowest) when viewed along the bond toward the lowest priority group. The priority of groups is based upon their atomic number (in order of decreasing atomic number). A partial list of priorities and a discussion of stereochemistry is contained in "Nomenclature of Organic Compounds: Principles and Practice", (J.H. Fletcher, et al., eds., 1974) at pages 103-120

As used herein the term "(1-6C)alkyl" refers to a straight or branched, monovalent, saturated aliphatic chain of 1 to 6 carbon atoms and includes, but is not limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, t-butyl, pentyl, isopentyl, and hexyl. The term "(1-6C)alkyl" includes within its definition the term "(1-4C)alkyl".

As used herein, the terms "Me", "Et", "Pr", "iPr", "Bu" and "t-Bu" refer to methyl, ethyl, propyl, isopropyl, butyl and tert-butyl respectively.

As used herein, the terms "Halo", "Halide" or "Hal" refers to a chlorine, bromine, iodine or fluorine atom, unless otherwise specified herein.

As used herein, the term "Ph" refers to a phenyl group.

As used herein the term "(2-4C)alkenyl" refers to a straight or branched, monovalent, unsaturated aliphatic chain having from two to four carbon atoms. Typical (2-4C)alkenyl groups include ethenyl (also known as vinyl), 1-methylethenyl, 1-methyl-1-propenyl, 1-butenyl, 2-methyl-2-propenyl, 1-propenyl, 2-propenyl, 2-butenyl, and the like.

As used herein the term "-(1-6C)alkoxy" refers to a straight or branched alkyl chain having from one to six carbon atoms attached to an oxygen atom. Typical -(1-6C)alkoxy groups include methoxy, ethoxy, propoxy, isopropoxy, butoxy, t-butoxy, pentoxy and the like. The term "-(1-6C)alkoxy" includes within its definition the term "-(1-4C)alkoxy".

As used herein the term "(2-4C)alkenyloxy" refers to a straight or branched unsaturated aliphatic chain having from two to four carbon atoms which is attached to an oxygen atom.

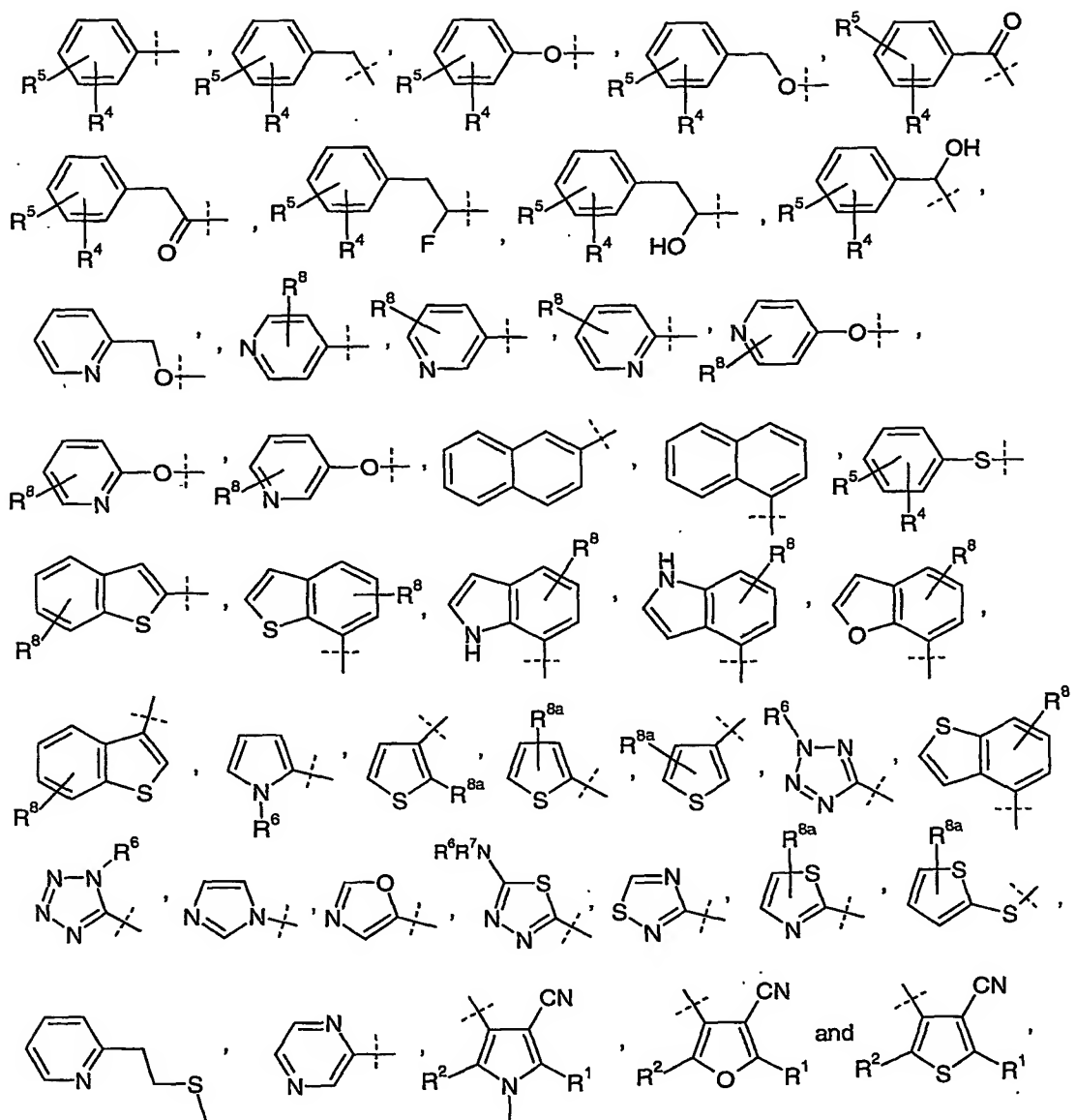
As used herein the term "(3-8C)cycloalkyl" refers to a saturated hydrocarbon ring structure containing from three to eight carbon atoms. Typical C<sub>3</sub>-C<sub>8</sub> cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl, and the like. . The term "(3-8C)cycloalkyl" includes within its definition the term "(4-7C)cycloalkyl" and "(3-6C)cycloalkyl".

As used herein the term "(1-20C)alkyl" refers to a straight or branched, monovalent, saturated aliphatic chain of 1 to 20 carbon atoms and includes, but is not limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, t-butyl, pentyl, isopentyl, hexyl, 3-methylpentyl, 2-ethylbutyl, n-heptyl, n-octyl, n-nonyl, n-decyl, n-undecyl, n-dodecyl, n-tridecyl, n-tetradecyl, n-pentadecyl, n-hexadecyl, n-heptadecyl, n-nonadecyl, n-eicosyl and the like.

As used herein the term "(2-6C)alkenyl" refers to a straight or branched, monovalent, unsaturated aliphatic chain having from two to six carbon atoms. Typical (2-6C)alkenyl groups include ethenyl (also known as vinyl), 1-methylethenyl, 1-methyl-1-propenyl, 1-butenyl, 1-hexenyl, 2-methyl-2-propenyl, 1-propenyl, 2-propenyl, 2-butenyl, 2-pentenyl, and the like.

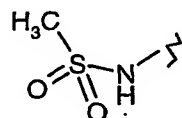
As used herein, the terms "aryl" or "Ar" refer to a carbocyclic or heterocyclic group which may contain one or more fused or non-fused phenyl rings and includes, for example, phenyl, biphenyl, 1- or 2-naphthyl, 1,2-dihydronaphthyl, 1,2,3,4-tetrahydronaphthyl, and the like. In addition, the aryl group may be substituted or unsubstituted as set forth herein. The terms "aryl" or "Ar" include, but are not limited to the following:





wherein the substituents are as defined herein.

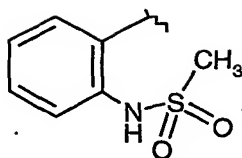
As used herein, the term “(methylsulfonylamino)” refers to the following structure:



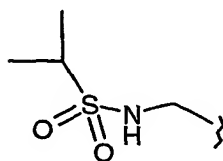
5

As used herein, the term “2-(Methylsulfonylamino)phenyl” refers to the following structure:

-30-

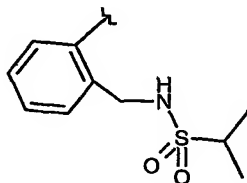


As used herein, the term “propane-2-sulfonylamino-methyl” refers to the following structure:

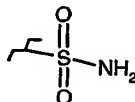


5

As used herein, the term “2-(propane-2-sulfonylamino-methyl)phenyl” refers to the following structure:

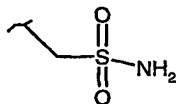


As used herein, the term “sulfamoyl” refers to the following structure:

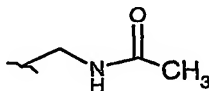


10

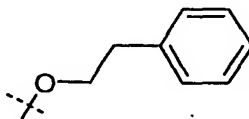
As used herein, the term “methylsulfamoyl” refers to the following structure:



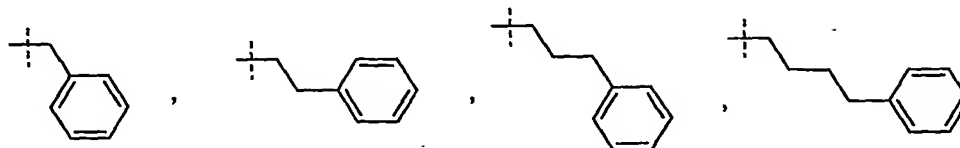
As used herein, the term “acetylamino-methyl” refers to the following structure:



15 As used herein, the term “phenethyloxy” refers to the following structure:

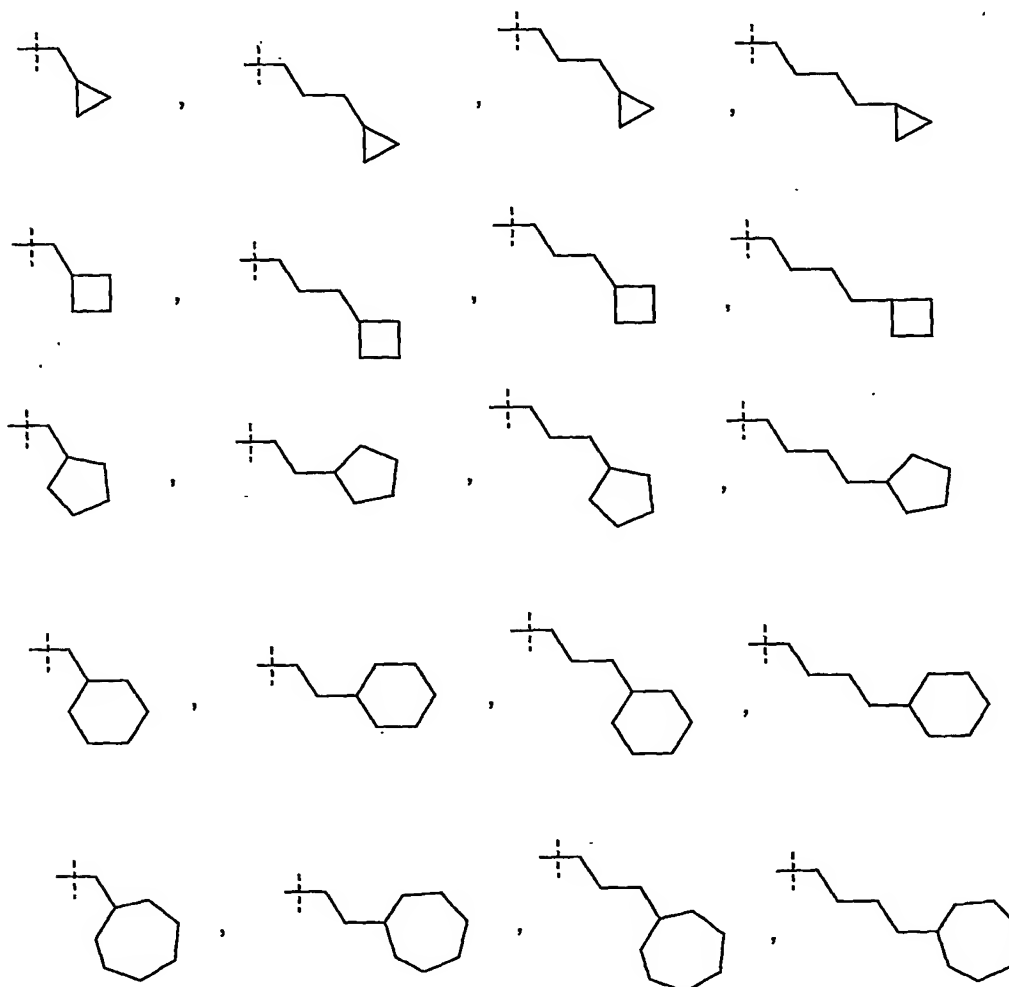


As used herein, the term “(1-6C)alkylaryl” includes the following:



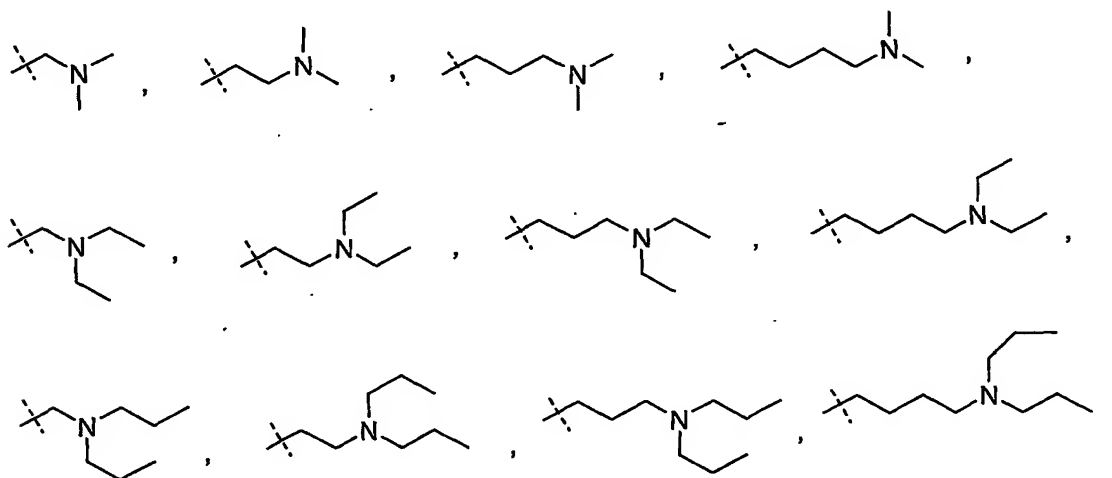
and the like.

- 5 As used herein, the term “-(1-6C)alkyl(3-8C)cycloalkyl” refers to a straight or branched, monovalent, saturated aliphatic chain of 1 to 6 carbon atoms which has a (3-8C)cycloalkyl attached to the aliphatic chain. Included within the term “-(1-6C)alkyl(3-8C)cycloalkyl” are the following:



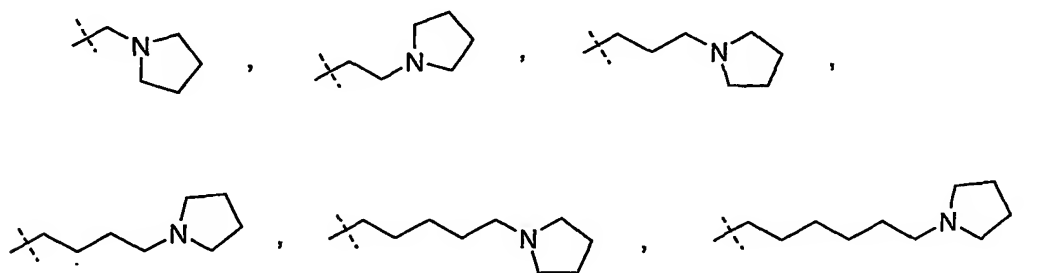
As used herein the term "N,N-(1-6C)dialkylamine" refers to a nitrogen atom substituted with two straight or branched, monovalent, saturated aliphatic chains of 1 to 6 carbon atoms. Included within the term "N,N-(1-6C)dialkylamine" are  $-N(CH_3)_2$ ,  $-N(CH_2CH_3)_2$ ,  $-N(CH_2CH_2CH_3)_2$ ,  $-N(CH_2CH_2CH_2CH_3)_2$ , and the like.

5 As used herein the term "-(1-6C)alkyl-N,N-(1-6C)dialkylamine" refers to straight or branched, monovalent, saturated aliphatic chain of 1 to 6 carbon atoms which has an N,N-(1-6C)dialkylamine attached to the aliphatic chain. Included within the term "-(1-6C)alkyl-N,N-(1-6C)dialkylamine" are the following:



10 and the like.

As used herein the term "-(1-6C)alkyl-pyrrolidine" refers to a straight or branched, monovalent, saturated aliphatic chain of 1 to 6 carbon atoms which has a pyrrolidine attached to the aliphatic chain. Included within the scope of the term "-(1-6C)alkyl-pyrrolidine" are the following:

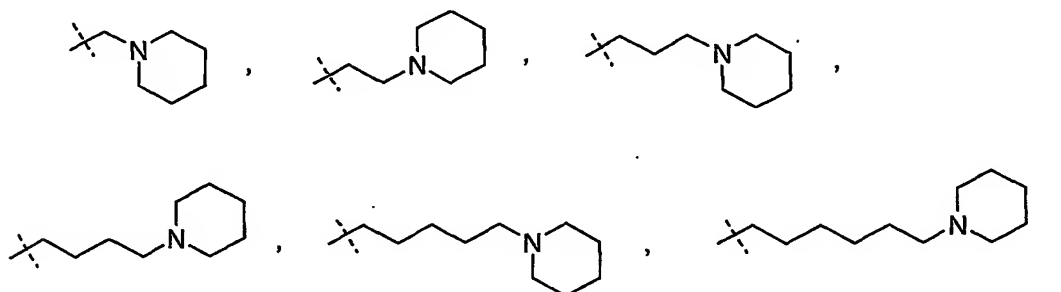


15

and the like.

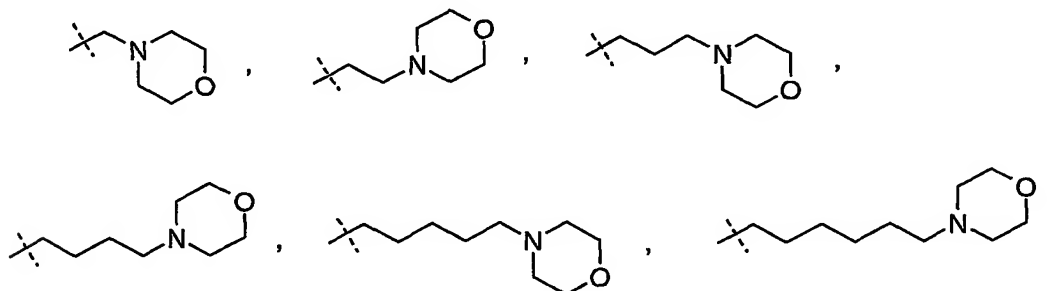
As used herein the term "-(1-6C)alkyl-piperidine" refers to a straight or branched, monovalent, saturated aliphatic chain of 1 to 6 carbon atoms which has a piperidine

attached to the aliphatic chain. Included within the scope of the term “-(1-6C)alkyl-piperidine” are the following:



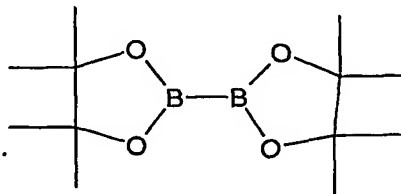
and the like.

- 5 As used herein the term “-(1-6C)alkyl-morpholine” refers to a straight or branched, monovalent, saturated aliphatic chain of 1 to 6 carbon atoms which has a morpholine attached to the aliphatic chain. Included within the scope of the term “-(1-6C)alkyl-morpholine” are the following:



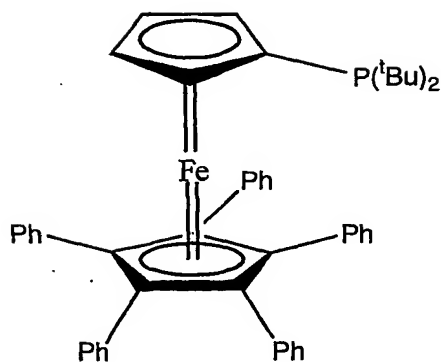
- 10 and the like.

As used herein the term “bis(pinacolato)diboron” refers to the following structure:

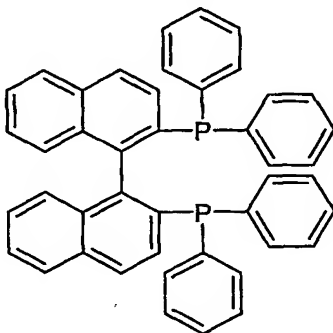


- 15 As used herein, the term “Hartwig’s Ligand” refers to the following compound:

-34-

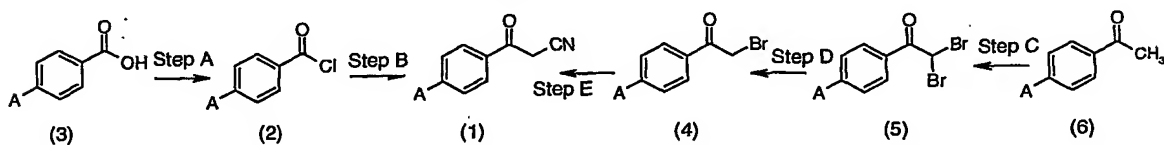


As used herein, "BINAP" refers to the following compound:



- 5 The compounds of Formula I and Formula II can be prepared by one of ordinary skill in the art following art recognized techniques and procedures. More specifically, compounds of Formula I and Formula II can be prepared as set forth in the schemes, methods, and examples set forth below. The reagents and starting materials are readily available to one of ordinary skill in the art. All substituents, unless otherwise specified,
- 10 are as previously defined.

### Scheme I



- 15 In Scheme I, step A, the suitable benzoic acid of structure (3) is combined with an acid chloride under conditions well known in the art to provide the benzoyl chloride of structure (2).

In Scheme I, step B, the benzoyl chloride of structure (2), is combined with cyanoacetic acid under conditions well known in the art to provide the propionitrile of structure (1) where A is as defined within. More specifically, butyllithium (4 molar excess) is added to a stirring solution of benzoyl chloride of structure (2) (2 molar excess) in a suitable solvent such as THF at about  $-78^{\circ}\text{C}$ . The temperature is raised to about  $0^{\circ}\text{C}$  and then cooled to about  $-78^{\circ}\text{C}$ . The benzoyl chloride of structure (2) in a solution of THF is added dropwise. The reaction is allowed to rise to room temperature over a period of one hour. Hydrochloric acid is added and the propionitrile of structure (1) is isolated using techniques well known in the art. Commercially available benzoyl chlorides of structure (2) include but are not limited to methoxybenzoyl chloride, nitrobenzoyl chloride, iodobenzoyl chloride

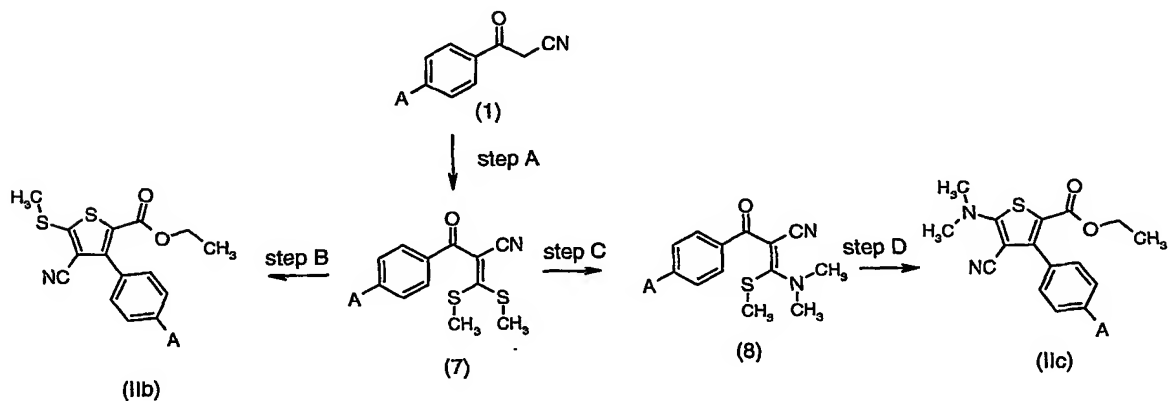
Alternatively, the propionitrile of structure (1) can be prepared by starting with the acetophenone of structure (6). In Scheme I, step C. The suitable acetophenone of structure (6) is dissolved in concentrated sulfuric acid and cooled to about  $0^{\circ}\text{C}$ . Bromine is then added and the reaction is allowed to warm to room temperature and stir for approximately 6 hours. The reaction is quenched and the resulting dibromo of structure (5) precipitates and is isolated using techniques well known in the art, for example, collection of the resulting solids by filtration, rinsing the solids with water, and drying to provide the dibromo ethanone of structure (5).

In Scheme I, step D, the bromo ethanone of structure (4) is prepared from the dibromo ethanone of structure (5) by conditions well known in the literature. More specifically, the dibromo ethanone of structure (5) is dissolved in a suitable organic solvent such as THF and cooled to about  $0^{\circ}\text{C}$ . The solution is treated with diethylphosphite and triethylamine and allowed to come to room temperature. After quenching after 6 hours with water, the resulting bromo of structure (4) precipitates and is isolated using techniques well known in the art, for example, collection of the resulting solids by filtration, rinsing the solids with water, and drying to provide the bromo of structure (4).

In Scheme I, step E, the propionitrile of structure (1) is formed by the nucleophilic displacement of the bromide of structure (4) with sodium cyanide in an appropriate solvent such as acetonitrile. The propionitrile of structure (1) is isolated using techniques well known in the art, such as adding ethyl acetate to the reaction mixture. The organic

layer is washed with saturated NaCl solution, dried over anhydrous magnesium sulfate, filtered, and concentrated to provide the propionitrile of structure (1).

Scheme II



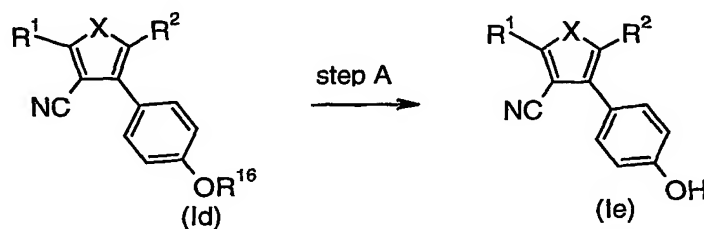
In Scheme II, step A, the compound of structure (7) is prepared from propionitrile of structure (1) under conditions well known in the art. More specifically, the compound of structure (1) is stirred with about 1 equivalent of carbon disulfide in an appropriate solvent such as DMSO. The reaction mixture is cooled to about  $-15^{\circ}\text{C}$  and about 2 to 2.4 equivalents of sodium hydride is added and the reaction mixture is warmed to room temperature for about 2.5 hours. The reaction mixture is then cooled to about  $-15^{\circ}\text{C}$  and iodomethane is added dropwise and the reaction is stirred for about 2 hours to about 24 hours and then quench with water. The compound of structure (7) is then isolated and purified using techniques well known in the art, such as extraction with a suitable organic solvent, such as ethyl acetate. The organic extracts are combined, washed with sat. NaCl, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum to provide the crude compound of structure (7). The crude compound of structure (7) can be purified by techniques well known in the art, such as silica gel chromatography.

In Scheme II, step C, the compound of structure (8) is prepared from the compound of structure (7) under conditions well known in the art. More specifically, the compound of structure (7) is stirred in an appropriate solvent such as acetonitrile at room temperature. An amine such as dimethylamine is added to the solution and the reaction mixture is allowed to stir for approximately 12 hours. The compound of structure (8) is isolated by removing the solvent in vacuo.

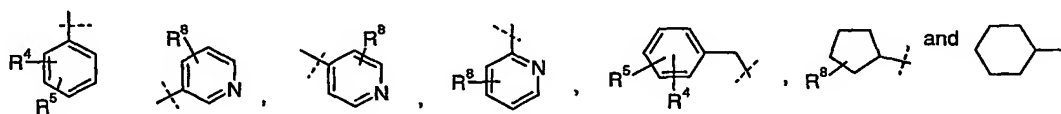


In Scheme II, steps B and D, the compounds of formula (IIb) and (IIc) are prepared from compounds of structure (7) and (8), respectively. The compound of structure (7) or (8) are combined with about 1.1 equivalents of ethylthioglycolate in suitable solvent such as ethanol. An appropriate base such as triethylamine or potassium acetate (approximately 1.1 to 3 equivalents) is added. The reaction mixture is heated to reflux for about 0.5 to 2 hours and immediately removed from the heat when the reflux is reached. The reaction is then cooled and the compounds of formula (IIb) or (IIc) are isolated using techniques well known in the art, for example, collection of the resulting solids from the partial evaporation of the solvent and rinsing the solids with cold ethanol to provide the compounds of formula (IIb) or (IIc).

### Scheme III

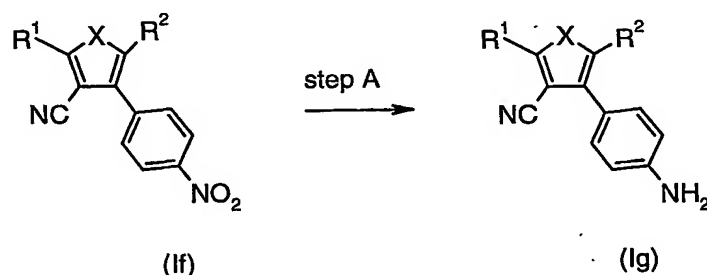


In Scheme III, step A, when the A substituent of the compound of formula (I) is a phenyl ether such as the compound of formula (Id), the phenyl ether is readily converted to the compound of formula (Ie), wherein R<sup>16</sup> represents -(1-4C)alkyl, -(2-4C)alkenyl, -(CH<sub>2</sub>)<sub>n</sub>CN, SO<sub>2</sub>CF<sub>3</sub>,



under deprotection conditions. See for example Theodora Greene, "Protective Groups in Organic Synthesis," John Wiley & Sons, Inc, pages 143-169 (1991). More specifically, for example, the compound of formula (Id) is dissolved in methylene chloride and cooled to about -78 °C and boron tribromide is added. The reaction mixture is allowed to stir at about -20 °C for about 16 hours. The product is then isolated and purified using techniques well known to one of ordinary skill in the art, such as extraction techniques, and chromatography. For example, the above reaction is diluted with water, dried over anhydrous sodium sulfate, filtered and concentrated under vacuum to provide the

compound of formula (Ie). A phenyl sulfonate ester, for example, formed by reaction of a phenol with a sulfonyl chloride in pyridine or aqueous sodium hydroxide, is cleaved by warming in aqueous sodium hydroxide to provide the compound of formula (Ie). A benzyl ether is deprotected for example, by catalytic hydrogenation in a suitable solvent  
5 such as methanol, ethyl acetate, acetic anhydride-benzene to provide the compound of formula (Ie).

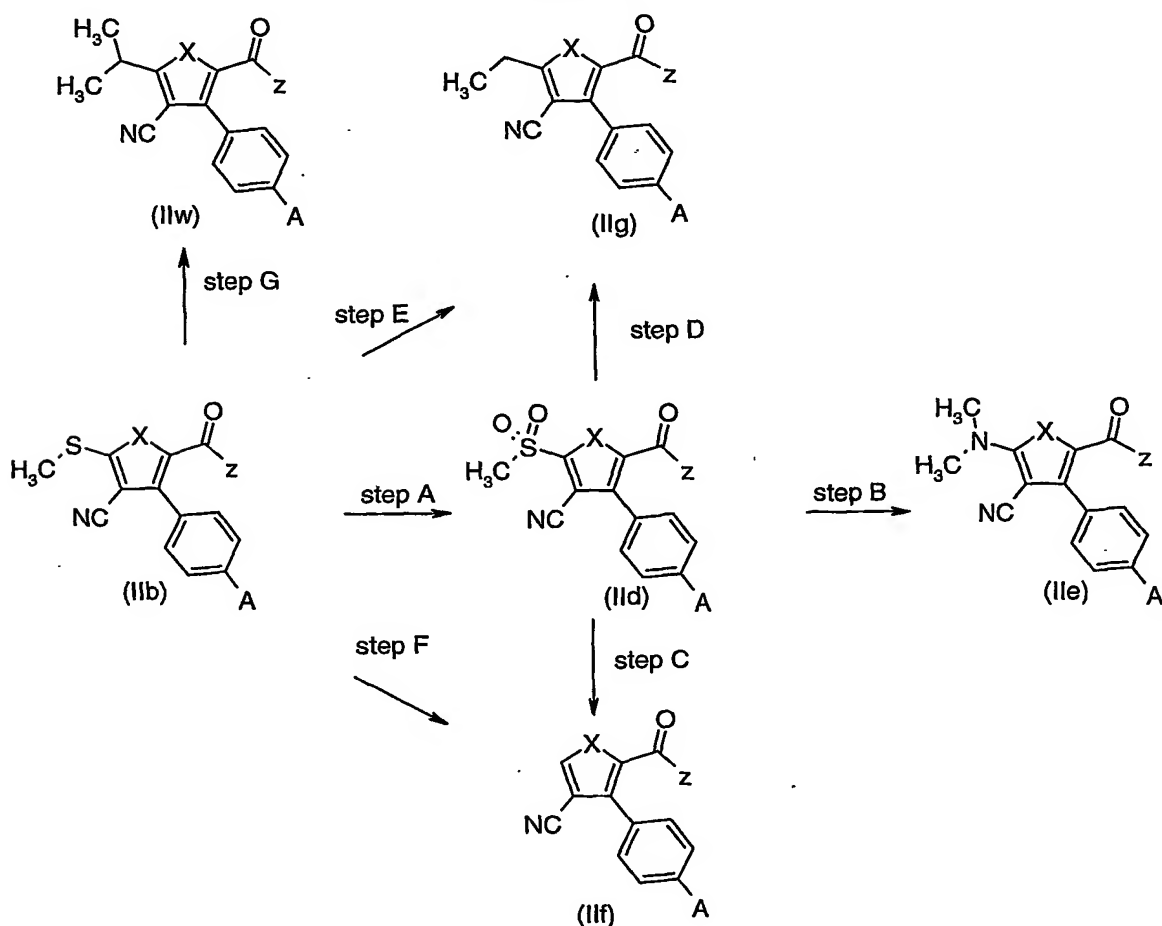
Scheme IV

In Scheme IV, step A when the A substituent of the compound of formula (I) or compound of formula (II) is a nitro group such as the compound of formula (If), the nitro group is readily converted to the compound of formula (Ig) under reducing conditions well known in the art. For example, the nitro compound is dissolved in a suitable solvent such as ethanol and a reducing agent such as tin chloride is added. The reaction can be  
15 heated to about 75 °C for about 30 minutes and then allowed to proceed overnight at room temperature. One can also monitor the progress of the reaction by methods known in the art, for example thin layer chromatography. The product is then isolated and purified using techniques well known to one of ordinary skill in the art, such as extraction techniques and chromatography. For example, the above reaction mixture is diluted with  
20 a saturated solution of sodium bicarbonate. The product is extracted with a suitable organic solvent, such as ethyl acetate, dried over anhydrous sodium sulfate, filtered, and concentrated under vacuum to provide the compound of formula (Ig).

The amino group of the compound of formula (Ig) can be further transformed by methods well known in the art. For example, the amino group of the compound of  
25 formula (Ig) can be transformed into an amide by reacting the amino group with a suitable acyl chloride or anhydride in the presence of a base such as triethylamine. The amino function of the compound of formula (Ig) can be further transformed into a sulfonamide

by reacting the amino group with a suitable sulfonyl chloride in the presence of pyridine or aqueous base such as triethylamine. The amino function of the compound of formula (Ig) can be alkylated to form a primary amine by reductive amination by forming the imine with a suitable aldehyde in an appropriate solvent such as methanol or ethanol. The reduction of the imine is carried out in an appropriate solvent such as methanol or ethanol and a suitable reducing agent such as sodium cyanoborohydride. A secondary amine can be formed by reacting the amine with the appropriate halide such as methyl iodide in the presence of a base such as potassium carbonate.

Scheme V



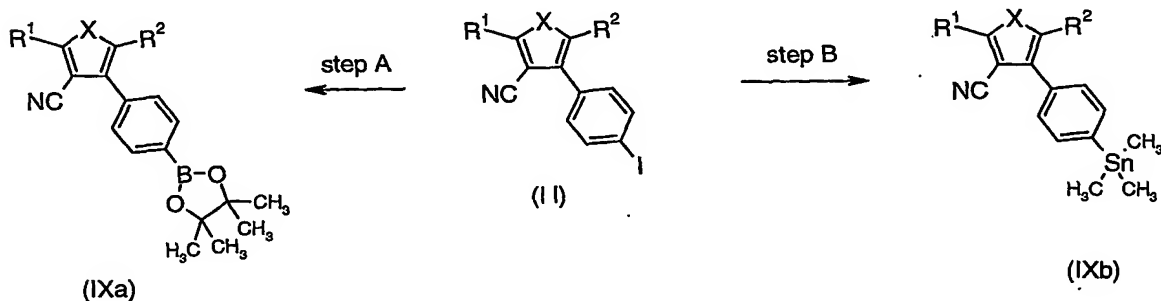
In Scheme V, step A, the compound of formula (IId) can be synthesized from the compound of formula (IIb) by oxidation methods known in the art. More specifically, for example the compound of formula (IIb) are dissolved in a suitable solvent such as methylene chloride and cooled to about 0 °C. An oxidizing agent for example, three

equivalents of m-chloroperbenzoic acid is added, and the reaction mixture is allowed to stir at room temperature for about three days or until the reaction is complete. The product is then isolated and purified using techniques well known to one of ordinary skill in the art, such as extraction techniques and chromatography. For example, the above reaction is diluted with a suitable organic solvent, such as methylene chloride, washed with saturated sodium bicarbonate, brine, dried over anhydrous magnesium sulfate, filtered and concentrated under vacuum to provide the compound of formula (IIId).

In Scheme V, the compound of formula (IIId) can be subjected to nucleophilic and reduction conditions to form the compound of formula (IIe, IIg, IIh). In Scheme V, step B, the compound of formula (IIe) can be prepared by dissolving the sulfonyl compound of formula (IIId) in a suitable solvent such as tetrahydrofuran then adding the base, dimethyl amine, and stirring for about 2 hours. The reaction can be concentrated under vacuum and purified if necessary to provide the compound of formula (IIe).

In Scheme V, steps C, D, E, F and G, the compound of formula (IIg) and the compound of formula (IIh) and the compound of formula (IIw) can be prepared by reacting the compound of formula (IIb) and the compound of formula (IIId) under reducing conditions, for example a suitable reducing agent would be sodium borohydride or diethylzinc or isopropyl zinc with an optional catalyst such as 1,3-bis-(diphenylphosphino)propane nickel (II) chloride and an appropriate solvent would be ethanol or methylene chloride. Also Na-Hg in the presence of Na<sub>2</sub>HPO<sub>4</sub> in an appropriate solvent can be utilized. Alternative examples for conditions can be found in Larock "Comprehensive Organic Transformations 2<sup>nd</sup> edition" pages 53-60, 1999.

Scheme VI

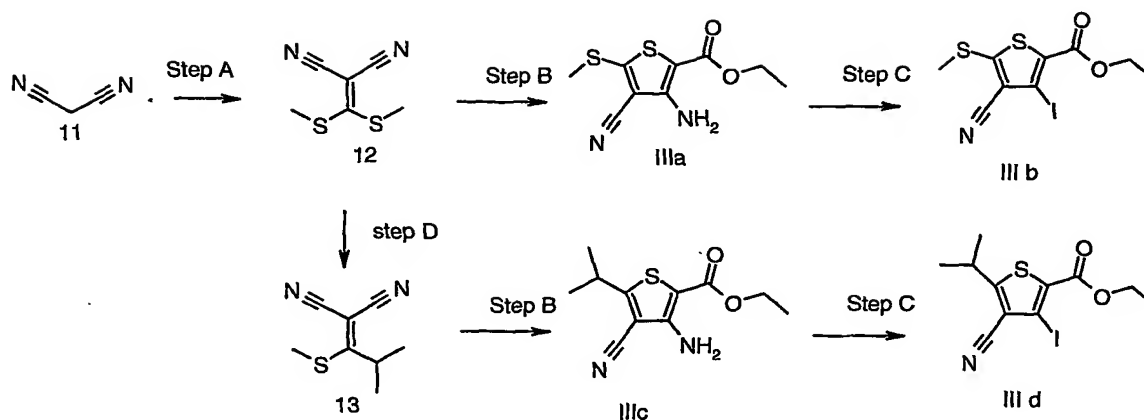


In Scheme VI, step A, the compound of formula (IXa) can be prepared from the compound of formula (I) by methods known in the art. For example, the iodo or bromo

compound of formula (I) is dissolved in an appropriate solvent such as acetonitrile or dimethylsulfoxide and a base such as triethylamine or potassium acetate is added. A catalyst such as [1,1'-bis(disphenylphosphino)-ferrocene]dichloropalladium(II) complex and a borane such as bis(pinacolato)borane are added. Under a nitrogen atmosphere, the reaction is heated to reflux for about 5 to 20 hours. The product is then isolated using techniques well known to one of ordinary skill in the art, such as extraction techniques. For example, the above reaction is cooled, diluted with a suitable organic solvent, such as ethyl acetate, washed with water, brine, dried over anhydrous sodium sulfate, filtered through Celite®, and concentrated under vacuum to provide the crude compound of formula (IXa). An additional acid wash such as a dilute acid wash might be necessary. The crude compound of formula (IXa) can be purified by techniques well known in the art, such as silica gel chromatography using a solvent mixture, such as ethyl acetate:hexanes.

In Scheme VI, step B, the compound of formula (IXb) can be prepared from the compound of formula (II) by methods known in the art. For example, the iodo compound is dissolved in dimethylformamide and a catalyst such as dichlorobis(triphenylphosphine)-palladium(II) and the tin compound such as hexamethylditin are added. Under a nitrogen atmosphere, the reaction is heated to about 80°C for about two hours. The product is then isolated and purified using techniques well known to one of ordinary skill in the art, such as extraction techniques and chromatography. For example, the above reaction mixture is diluted with water. The product is extracted with a suitable organic solvent, such as ethyl acetate, dried over anhydrous sodium sulfate, filtered, and concentrated under vacuum to provide the crude compound of formula (IXb). The crude compound of Formula (IXb) can be purified by techniques well known in the art, such as silica gel chromatography using a eluent, such as ethyl acetate:hexanes.

Scheme VII



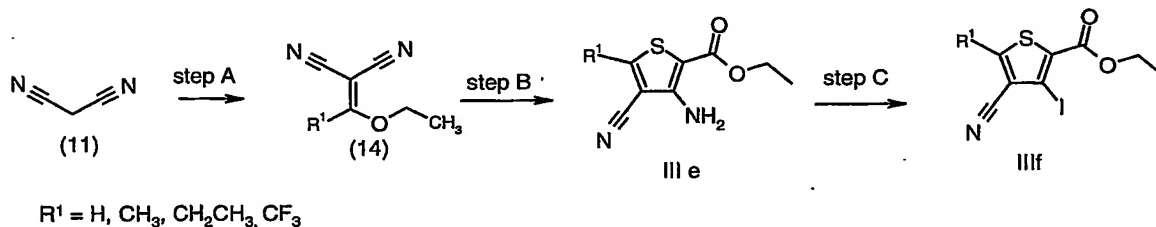
5 In Scheme VII, step A, the compound of structure (12) is prepared from malononitrile under conditions well known in the art. More specifically, the anion of malononitrile is formed by adding about 2.1 equivalents of sodium hydride under a nitrogen atmosphere at about -15 °C. After anion formation, about 1 equivalent of carbon disulfide is added and the reaction mixture is warmed to room temperature. After about 10 2.5 hours additional sodium hydride is added and the temperature is maintained at room temperature. Cool the reaction to about -15 °C and add about 2 equivalents of iodomethane dropwise and stir the reaction for about 2 hours to about 24 hours and then quench with water. The desired intermediate of structure (12) precipitates and is collected by filtration and washed with water, partially air-dry, and washed with hexanes. The 15 crude product can be recrystallized from a suitable solvent such as 2-propanol, washed with cold 2-propanol and hexanes and isolated.

In Scheme VII, step B, the compounds of structure (IIIa) and (IIIc) are synthesized by combining compounds of structure (12) and (13) respectively, with ethylthioglycolate in an appropriate solvent such as ethanol. An appropriate base such as triethylamine or 20 potassium acetate is added. The reaction mixture is refluxed for about 30 minutes to 2 hours. Cool the reaction mixture to about 35 °C over about 45 minutes then cool to 3 °C over 20 minutes and maintain about 3°C for about 20 minutes. The precipitate that forms is isolated, washed with a solvent such as ethanol and ether and dried.

In Scheme VII, step C, the compounds of structure (IIIa) and (IIIc) are dissolved in an appropriate solvent such as acetonitrile and placed in a nitrogen atmosphere. An excess of methylene iodine is added and the reaction mixture is warmed to about 35 °C to 45°C. i-Amylnitrite is slowly added via an addition funnel. A vigorous reaction might  
 5 occur so care should be taken upon addition of the i-amyl nitrite. After about half of the i-amyl nitrite is added, the temperature is warmed to about 55 °C to initiate the reaction. Add the remaining i-amyl nitrite maintaining the reaction mixture at about 60 °C. After addition, stir for about 45 minutes at about room temperature to 45 °C. The reaction mixture is cooled to about 5 °C and hexanes are added. The resulting precipitate is  
 10 collected by filtration and washed with acetone/hexanes, diethyl ether/hexanes, and hexanes and dried to give the compounds of formula (III b) and (III d).

In Scheme VII, step D, the compound of structure (13) is prepared from the compound of structure (12) by reacting the compound of structure (12) with a magnesium chloride such as isopropylmagnesium chloride in an appropriate solvent such as  
 15 tetrahydrofuran and a temperature of about -40°C for about 18 to 24 hours. The reaction is quenched with ammonium chloride, extracted with a solvent such as ethyl acetate, dried over magnesium sulfate, remove solvents under vacuum and purified by chromatography using an eluent such as hexane and ethyl acetate to provide compound of formula (13).

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Scheme VIII

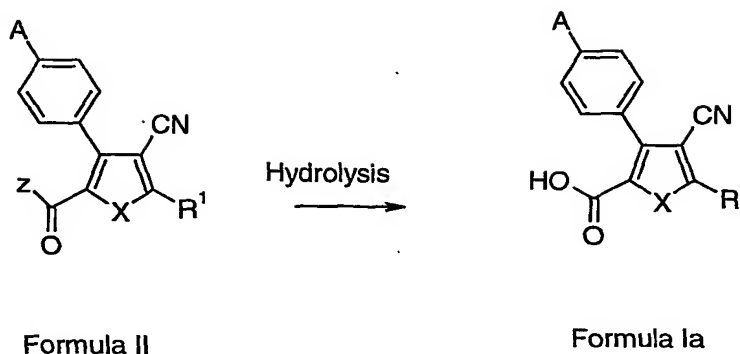
In Scheme VIII, step A, the compound of structure (14) is synthesized by methods known in the art. For example, malononitrile is mixed with the appropriate starting materials such as triethylorthopropionate, triethylorthoethylate, or diethoxymethoxyethane  
 25 in an appropriate solvent such as anhydrous dimethylsulfoxide. The reaction is refluxed under nitrogen for about 1.5 hours. The product is isolated by vacuum distillation at 10-

15 torr at 135-142 °C. The literature reference, Middleton, *J. Fluorine Chem.*, 20, 1982, p 397-418, can be followed for the synthesis of the compound of structure (14)  $R^1 = CF_3$ .

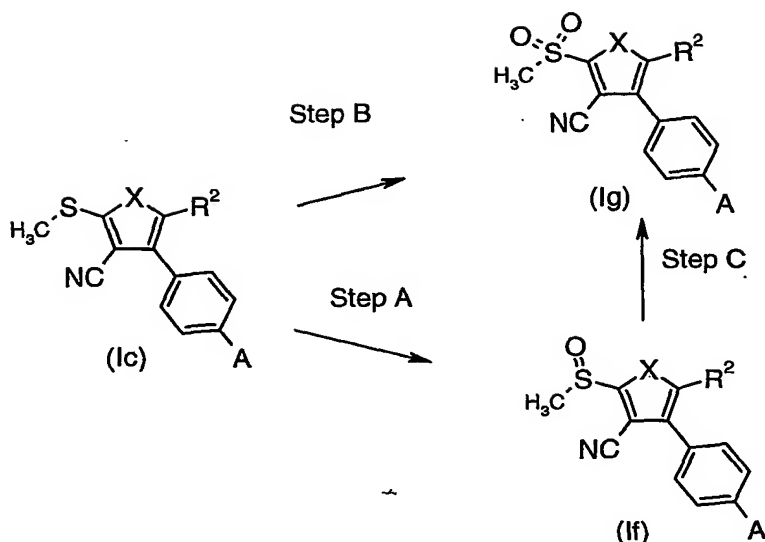
In Scheme VIII, step B, the compound of structure (III e) is synthesized by combining the compound of structure (14) with ethylthioglycolate in an appropriate solvent such as ethanol. An appropriate base such as potassium acetate or triethylamine is added. The reaction mixture is refluxed for about 30 minutes to 2 hours. The product can be isolated by adding water to the reaction mixture and cooling to 5 °C for about 1 hour. The precipitate that forms is isolated, washed with a solvent such as water/ethanol, and dried.

In Scheme VIII, step C, the compound of structure (IIIe) is dissolved in an appropriate solvent such as acetonitrile and placed in a nitrogen atmosphere. An excess of diiodo methane is added and the reaction mixture is warmed to about 35 to 45°C. i-Amylnitrite is slowly added via an addition funnel. A vigorous reaction might occur so care should be taken upon addition of the i-amyl nitrite. After about half of the i-amyl nitrite is added, the temperature is warmed to about 55 °C to initiate the reaction. Add the remaining i-amyl nitrite maintaining the reaction mixture at about 60 °C to about 80°C. After addition, stir for about 45 minutes at about room temperature to 45 °C. The reaction mixture is concentrated under vacuum, passed through a plug of silica gel eluting with methylene chloride, and concentrated under vacuum. The oil can be mixed with 2-propanol and hexanes and cooled to about 5 °C. The resulting crude precipitate is collected by filtration, rinsed with 2-propanol/hexane or hexane and dried at room temperature. The compound of structure (III f) is purified by silica gel chromatography using methylene chloride/ hexane solvent system. The product can also be recrystallized from a suitable solvent, such as from hexanes.



Scheme IX

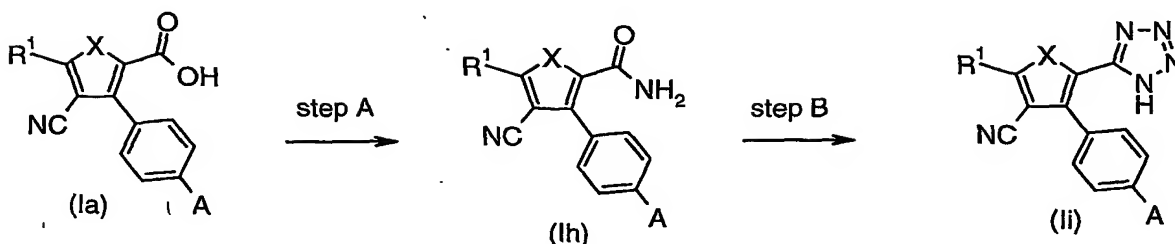
In Scheme IX, the compound of Formula II is converted to the carboxylic acid of Formula Ia under conditions well known in the art by treatment with a suitable hydrolysis agent, such as a suitable base or enzyme. For example, the compound of Formula (II) is dissolved in a suitable organic solvent or solvent mixture, such as THF, methanol, ethanol, and the like. The mixture is treated with water and a slight excess of a suitable base, such as lithium hydroxide, sodium hydroxide, potassium hydroxide, and the like, and stirred for about 1 to 18 hours at a temperature of about 25°C to about 60°C. The compound of Formula (Ia) is then isolated and purified by techniques well known in the art, such as extraction techniques and recrystallization. For example, the reaction mixture is acidified with a suitable acid, such as 1N HCl and the compound of Formula (Ia) is then extracted from the mixture with a suitable organic solvent, such as methylene chloride. The organic extracts are then combined, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum. The residue can then be purified by recrystallization from a suitable organic solvent such as ethyl acetate to provide purified the compound of Formula (Ia). If a precipitate forms when the acid is added the solid is collected by filtration to provide purified the compound of Formula (Ia).

Scheme X

In Scheme X, step A, the compound of formula (If) can be synthesized from the compound of formula (Ic) by oxidation methods known in the art. More specifically, for example the compound of formula (Ic) is dissolved in a suitable solvent such as methylene chloride and cooled to about 0 °C. An oxidizing agent for example, m-chloroperbenzoic acid of about 1.0 equivalent is added, and the reaction mixture is allowed to stir at room temperature for about three days or until the reaction is complete. The product is then isolated and purified using techniques well known to one of ordinary skill in the art, such as extraction techniques and chromatography. For example, the above reaction is diluted with a suitable organic solvent, such as methylene chloride, washed with saturated sodium bicarbonate, brine, dried over anhydrous magnesium sulfate, filtered and concentrated under vacuum to provide the compound of formula (If).

In Scheme X, step B, the compound of formula (Ig) can be synthesized from the compound of formula (If) by methods described for step A of Scheme X except that about 3.0 equivalents of the the oxidizing agent such as m-chloroperbenzoic acid is used.

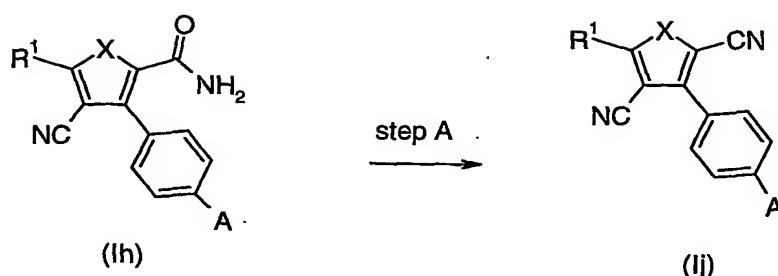
In Scheme X, step C the compound of formula (Ig) can be synthesized from the compound of formula (If) by methods described for step A of Scheme X except that about 1.5 equivalents of the the oxidizing agent such as m-chloroperbenzoic acid is used.

Scheme XI

In Scheme XI, step A, the carboxylic acid of the compound of formula (Ia) is converted to the primary amide of the compound of formula (Ih) under conditions well known in the art. For example, the compound of formula (Ia) is dissolved in a suitable organic solvent, such as methylene chloride or THF and treated with about 1.1 to 1.3 equivalents of oxalyl chloride at a temperature of about 0°C to 25°C followed by addition of a catalytic amount of DMF with stirring. The reaction mixture is allowed to stir for about 1 to 8 hours and then it is concentrated under reduced vacuum. The residue is then dissolved in a suitable organic solvent, such as methylene chloride or THF and treated with a slight excess of an ammonia hydroxide or ammonia/methanol solution at room temperature with stirring. A precipitate might form. The reaction mixture is allowed to stir for about 1 to 4 hours and then it is concentrated under vacuum and purified by techniques well known in the art, such as chromatography on silica gel with a suitable eluent, such as methanol/dichloromethane to provide the purified primary amide of the compound of formula (Ih).

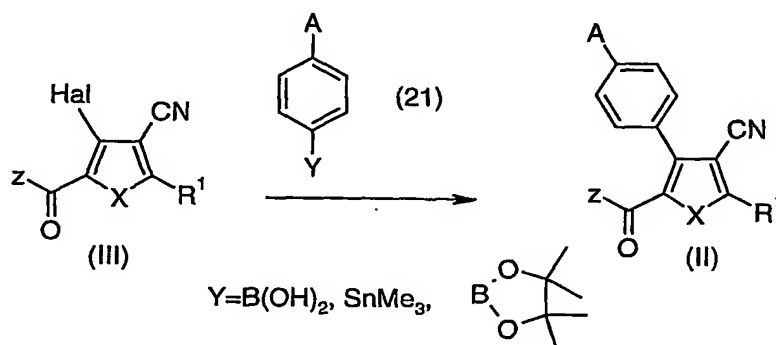
In Scheme XI, step B, the primary amide of the compound of formula (Ih) is converted to the tetrazole compound of formula (Ii) under standard conditions. For example, about 1 to 2 equivalents silicon tetrachloride and about 3 to 12 equivalents of sodium azide are combined in a suitable organic solvent, such as acetonitrile and stirred at room temperature for about 20 minutes. About 1 equivalent of the primary amide of the compound of formula (Ih) is added to the stirring mixture and the reaction mixture is heated at about 100°C for about 8 to 24 hours. The reaction is concentrated under vacuum and purified such as chromatography on silica gel with a suitable eluent, such as methanol/acetic acid /dichloromethane to provide the purified compound of formula (Ii).

## Scheme XII



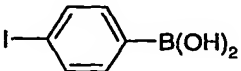
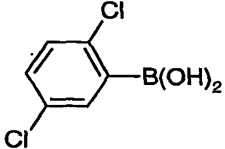
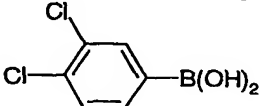
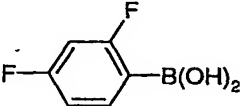
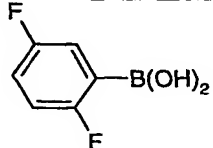
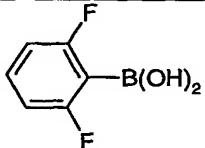
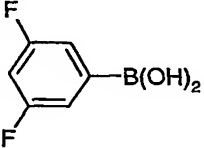
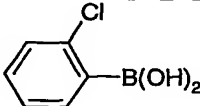
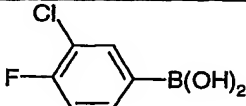
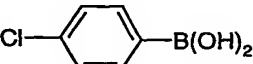
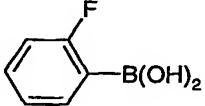
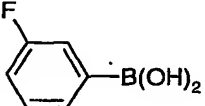
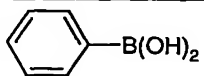
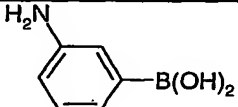
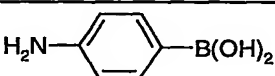
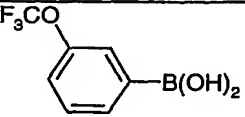
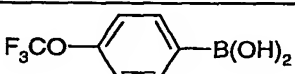
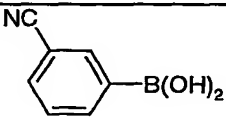
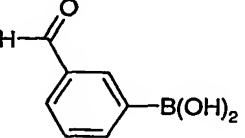
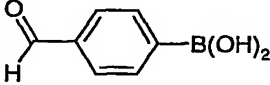
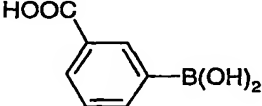
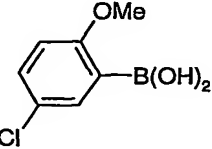
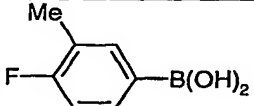
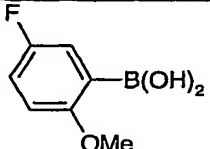
In Scheme XIII, step A, the primary amide of the compound of formula (Ih) is converted to the dicyano compound of formula (Ij) under standard conditions. For example, the amide is dissolved in a suitable solvent such as acetonitrile and paraformaldehyde and formic acid are added. The reaction mixture is heated for about 6 hours. The reaction is concentrated under vacuum and purified such as chromatography on silica gel with a suitable eluent, such as ethyl acetate/hexane to provide the purified dicyano compound of formula (Ij).

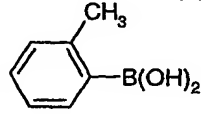
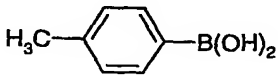
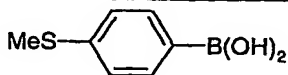
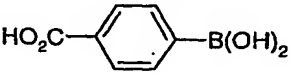
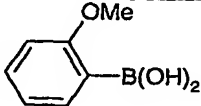
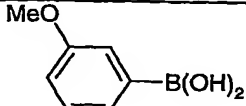
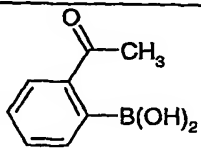
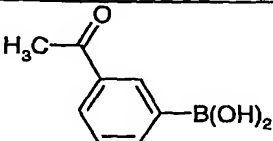
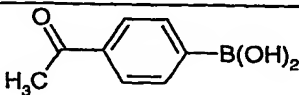
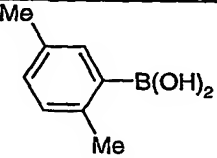
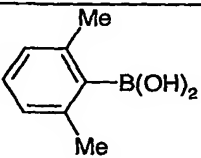
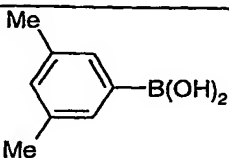
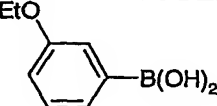
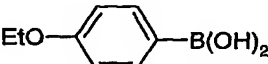
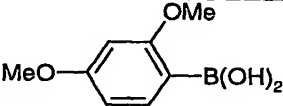
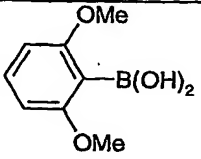
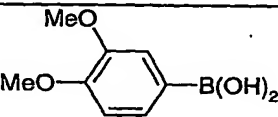
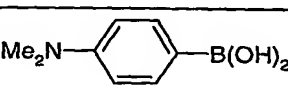
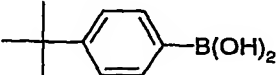
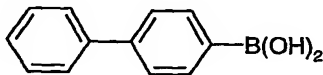
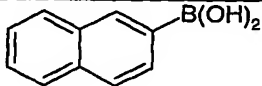
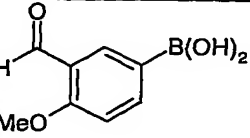
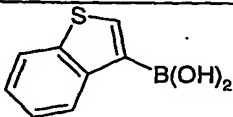
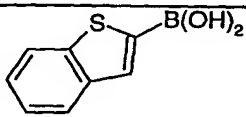
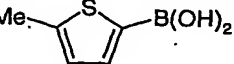
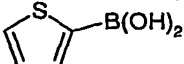
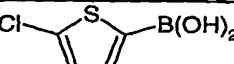
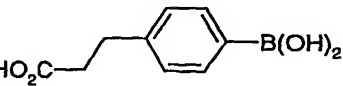
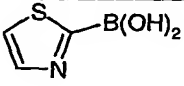
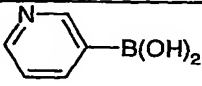
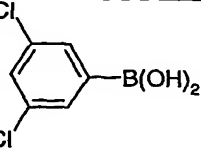
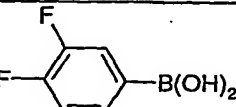
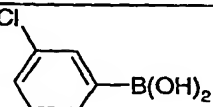
## Scheme XIII

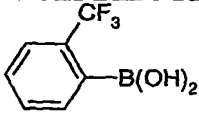
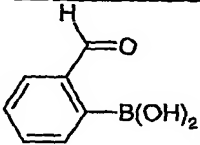

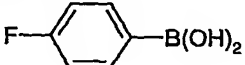
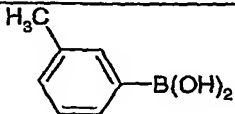
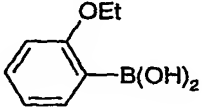
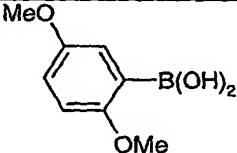
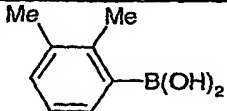
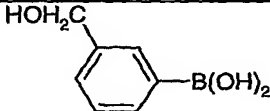
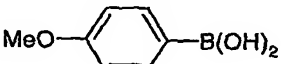
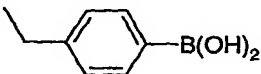
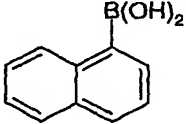
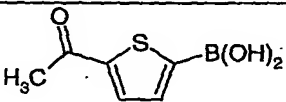
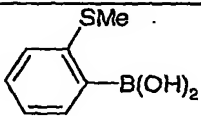
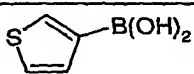
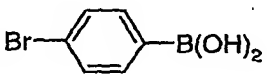
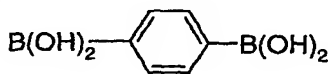
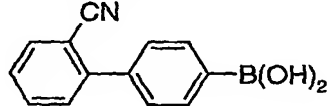
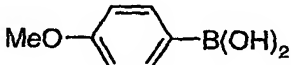
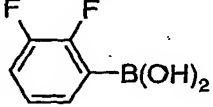
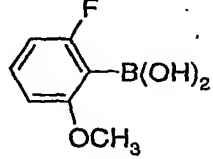
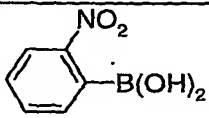
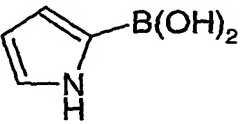
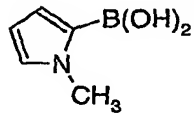
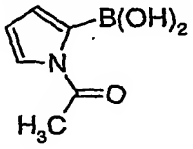
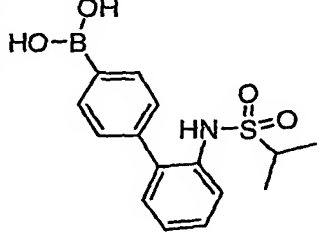
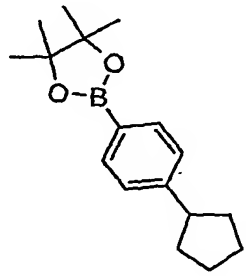


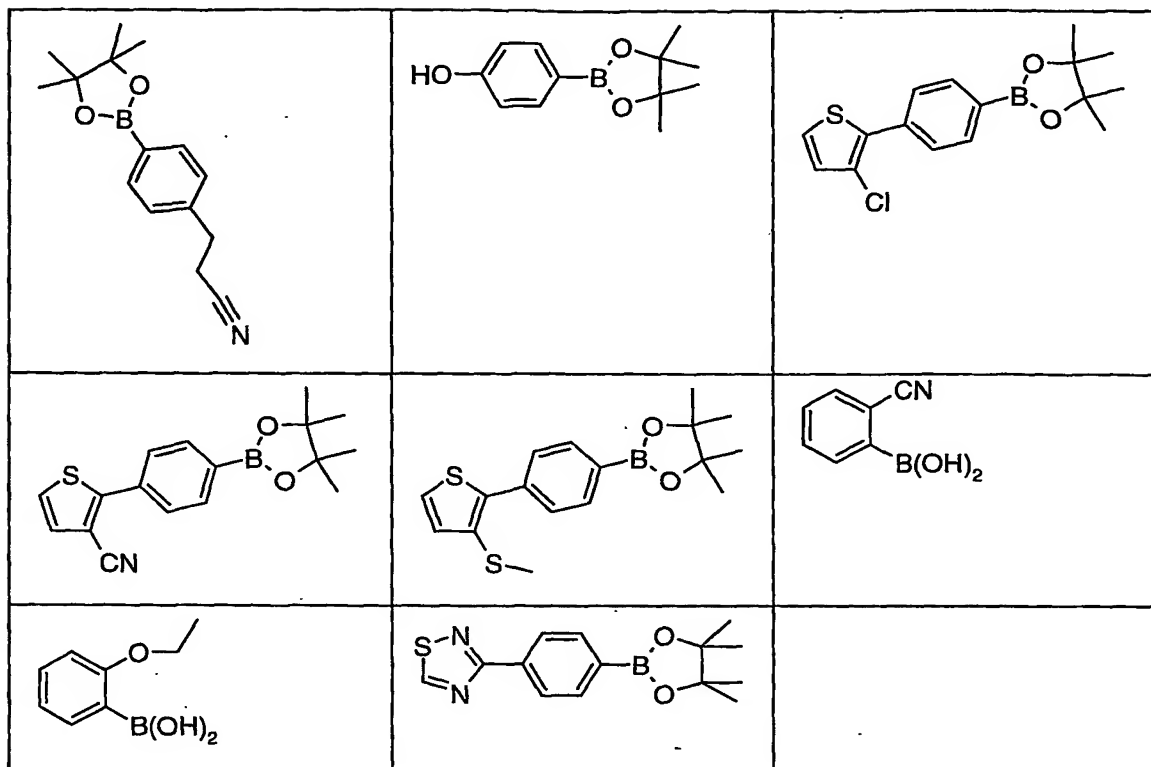
In Scheme XIII, the compound of structure (III), wherein Hal is iodo or bromo, is coupled to a suitable phenyl boronic acid of structure (21) or suitable phenyl boronic ester of structure (21) or suitable phenyl trimethylstannyl of structure (21), under Suzuki-Type or Stille-Type coupling reaction conditions well known to one of ordinary skill in the art to provide the compound of formula (II). See Suzuki, A., *Journal of Organometallic Chemistry*, 576, 147-168 (1999), and Miyaura and Suzuki, *Chemical Reviews*, 95, 2457-2483 (1995) for examples of general cross-coupling techniques and for methods for

preparing suitable starting materials and reagents. It is understood by one of ordinary skill in the art, that in general, a phenyl boronic ester can be used in place of the phenyl boronic acid of structure (21) in the palladium catalyzed cross-coupling reactions described herein. Examples of phenyl boronic acids of structure (21) and phenyl boronic ester of structure (21) include the following:



and the like. More specifically, the compound of structure (III) is combined with about 1.1 to 1.5 equivalents of the suitable phenyl boronic acid of structure (21) or the suitable phenyl boronic ester of structure (21) in a suitable organic solvent. Examples of suitable organic solvents include 1,4-dioxane, dimethoxyethane, benzene, toluene, acetone, ethanol, and the like. About 0.01 to 0.10 equivalents of a suitable catalyst, such as tetrakis(triphenylphosphine)palladium or [1,1-bis(diphenylphosphino)ferrocene] dichloro-

5 palladium(II) or palladium black and about 1.7 to 5 equivalents of a suitable base are added to the reaction mixture with stirring. Examples of suitable bases include 2M

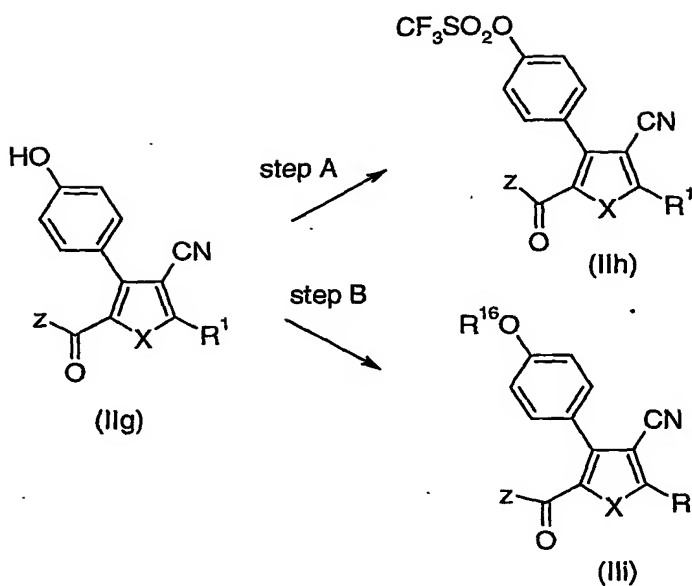
10  $\text{Na}_2\text{CO}_3$ ,  $\text{NaHCO}_3$ ,  $\text{Cs}_2\text{CO}_3$ ,  $\text{Ti}_2\text{CO}_3$ ,  $\text{K}_3\text{PO}_4$ ,  $\text{CsF}$ , triethylamine,  $\text{K}_2\text{CO}_3$ , and the like. The reaction is heated to about  $60^\circ\text{C}$  to  $100^\circ\text{C}$  for about 1 to 18 hours, then cooled to room temperature, optionally quenching with water. If solids form a filtering through Celite ® might be necessary. The phases are separated. The product is then isolated and purified by techniques well known in the art, such as extraction and chromatography. For

15 example, the aqueous phase is extracted with a suitable organic solvent, such as dichloromethane or ethyl acetate, the organic extracts are combined, washed with optional acid, water, brine, dried over anhydrous magnesium sulfate or sodium sulfate, filtered,



and concentrated under vacuum to provide the crude compound of Formula (II). This crude material, compound of Formula (II), can then be purified by flash chromatography on silica gel with a suitable eluent, such as ethyl acetate:hexane. Optionally, the organic extracts can be first concentrated under vacuum then the crude oil extracted with a  
5 suitable solvent such as heptane. The supernatant is decanted and the recovered oil is mixed with silica gel for about 3 minutes. The mixture is filtered and concentrated the filtrate under vacuum to obtain a solid. The solid can be triturated with a suitable solvent such as pentane and the solids are collected by filtration to provide the crude compound of Formula (II). The crude compound of Formula (II) can be purified by dissolving the solid  
10 in a mixture of pentane and cyclohexane and heating to about 44°C and adding silica gel and stirring for about 3 minutes. Filter the solution and concentrate the filtrate under vacuum to about 1/3 the volume to form a suspension. Collect the particles and wash the particles with a suitable solvent such as pentane and dry to provide the compound of Formula (II). Another option for the isolation of the product is to dilute the crude product  
15 with water and heat the solution to about 70 °C for about 15 minutes. Decant the aqueous and redilute with water and heat the solution to about 70 °C for about 15 minutes and filter. Isolate the solids and dissolve in a suitable solvent such as ethanol/water and heat to about 80 °C. Cool this solution slowly over 12 hours to 0 °C with slow stirring. Filter the precipitate through a filter such as a sintered glass and dry under vacuum and/or air-dry  
20 to afford the compound of Formula (II).

## Scheme XIV



In scheme XIV, step A, the compound of formula (IIg) are dissolved in a suitable solvent such as dichloromethane under a nitrogen atmosphere and a suitable base such as pyridine or sodium hydride is added and the reaction mixture is cooled to about  $-4^{\circ}\text{C}$  to  $-70^{\circ}\text{C}$ . Trifluoromethanesulfonic anhydride is added over about a 6 minute period. The reaction mixture is allowed to stir for about 1 hour. Additional base and anhydride might be needed in order to complete the reaction. Ethanol is added. After about 2 to 3 hours, the reaction is quenched with water. The product is then isolated and purified by techniques well known in the art, such as extraction and chromatography. For example, the aqueous phase is extracted with a suitable organic solvent, such as dichloromethane, the organic extracts are combined, washed with water, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum to provide the crude compound of formula (IIh). The powder is triturated with a suitable solvent such as ethyl acetate and hexane, filtered and dried to give the compound of formula (IIh).

In scheme XIV, step B, the compound of formula (IIIi) can be prepared by using methods well known in the art. For example, Larock "Comprehensive Organic Transformations 2<sup>nd</sup> edition" pp. 896-897, 1999 specifically discuss the formation of phenyl ethers from phenols of the compound of formula (IIg). More specifically, the phenol is dissolved in a suitable solvent such as acetonitrile, dimethylformamide, dimethylsulfoxide, or methylene chloride. About 1.1 to 1.5 equiv. of a suitable base such

as potassium carbonate, potassium hydroxide, sodium hydroxide or sodium hydride is added. The reaction mixture is then stirred at room temperature for about 15 minutes to 1 hour and then treated with about 1.5 equivalents of the suitable alkylating agent, such as  $R^{16}$ -Hal ( $R^{16}$  defined within and Hal= Br, Cl, I) and the reaction is heated to about reflux or stirred at room temperature for about 1 to 24 hours. Examples of suitable alkylating agents are methyl iodide, ethyl iodide, propyl iodide, isopropyl iodide, ethyl bromide, propyl bromide, butyl bromide, butyl chloride, tert-butyl bromide, cyclopropyl bromide, cyclohexyl bromide, bromoacetonitrile, 3-bromopropionitrile, 4-bromobutyronitrile, 2-cyanobenzyl bromide, 3-cyanobenzyl bromide, 4-cyanobenzyl bromide, 2-fluorobenzyl bromide, 3-fluorobenzyl bromide, 4-fluorobenzyl bromide, and the like. The product is then isolated and purified by techniques well known in the art, such as quenching the reaction mixture with water and extracting with a suitable solvent such as ethyl acetate. The organic layer is washed with water, saturated sodium chloride, dried over anhydrous magnesium sulfate, filtered, concentrated under vacuum to give the compounds of formula (Iii).

Alternatively, the phenol is dissolved in a suitable solvent such as toluene and cooled to about 0 °C. The appropriate alcohol,  $R^{16}$ -OH, is added along with the triphenylphosphine and approximately 1.5 to 2 equivalents of DIAD (Diisopropyl azodicarboxylate). The product is then isolated and purified by techniques well known in the art, such as letting the reaction warm slowly to room temperature, removing the solvent under vacuum and purified by chromatography to give the compound of formula (Iii).

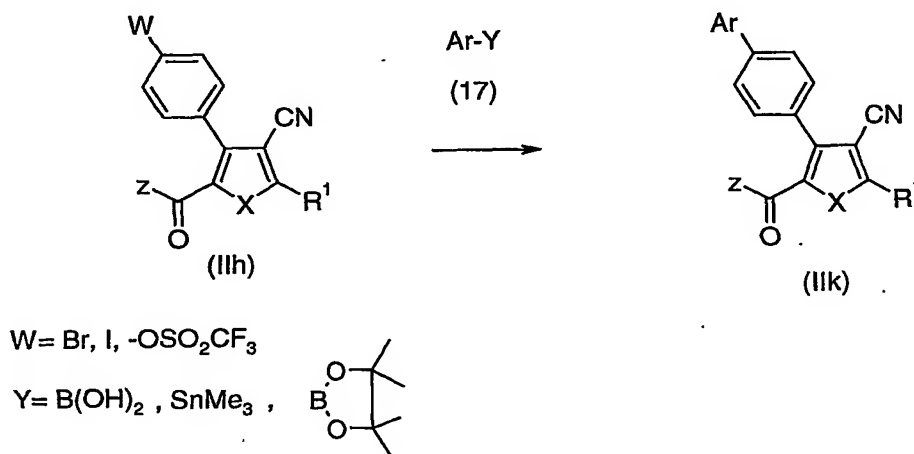
Alternatively, the phenol is dissolved in an appropriate solvent such as acetonitrile and treated with about 5 equivalents of potassium fluoride on alumina, a catalytic amount of a crown ether, such as 18-crown-6, and a suitable fluorosubstituted aryl derivative, such as 2-fluorobenzonitrile, 3-fluorobenzonitrile, 4-fluorobenzonitrile, 1-fluoro-2-nitrobenzene, 1-fluoro-3-nitrobenzene, 1-fluoro-4-nitrobenzene, and the like. The reaction mixture is heated to reflux for about 12 to 24 hours. The product is then isolated and purified by techniques well known in the art, such as letting the reaction cool to room temperature, partition the reaction mixture between a suitable solvent such as ethyl acetate or ether and water, and separating the aqueous layer and the alumina sediments. The organic phase is washed with saturated sodium chloride, dried over sodium sulfate,

filtered, and concentrated under vacuum to give the crude compound of formula (Iii). The crude material is purified by chromatography to give the compound of formula (Iii).

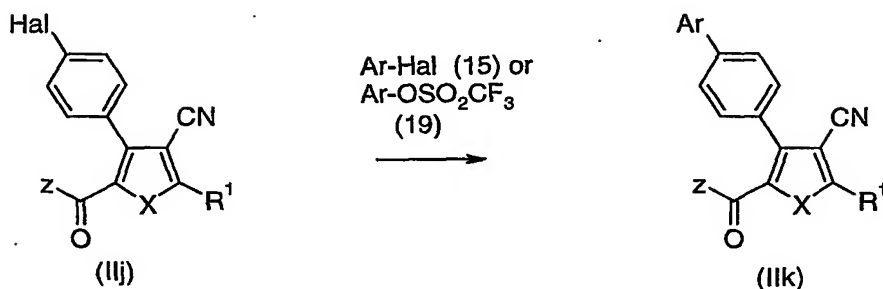
Alternatively, the phenol is dissolved in a suitable solvent such as methylene chloride and molecular sieves are optionally added along with a suitable aryl boronic acid, such as those disclosed herein, an example is 4-fluorophenylboronic acid and about 2 equivalents of copper(II) acetate. The reaction mixture is stirred of about 18 to about 24 hours. The product is then isolated and purified by techniques well known in the art, such as the reaction mixture is filtered through diatomaceous earth for example, concentrated under vacuum, and purified by chromatography to give the compound of formula (Iii).

The ester group can be transformed into the carboxylic acid group as described previously in Scheme IX.

#### Scheme XV

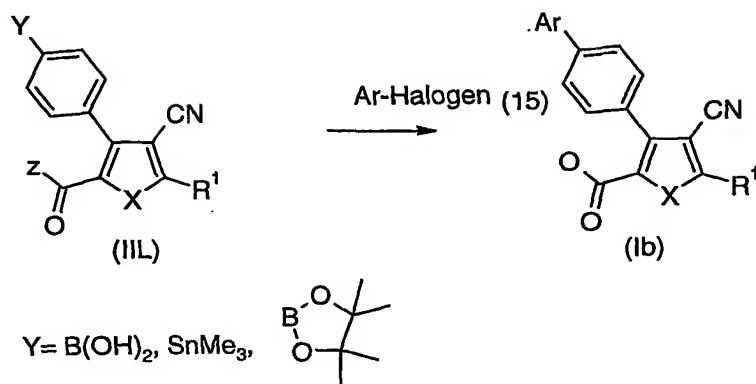


In Scheme XV, the compound of Formula (IIh) is coupled to a suitable aryl boronic acid of structure (17) or suitable aryl borate ester of structure (17), or suitable trimethyl stannyl of structure (17) wherein Ar represents a suitable aryl group, in a manner analogous to the procedure set forth in Scheme XIII to provide the compound of Formula (IIk).

Scheme XVI

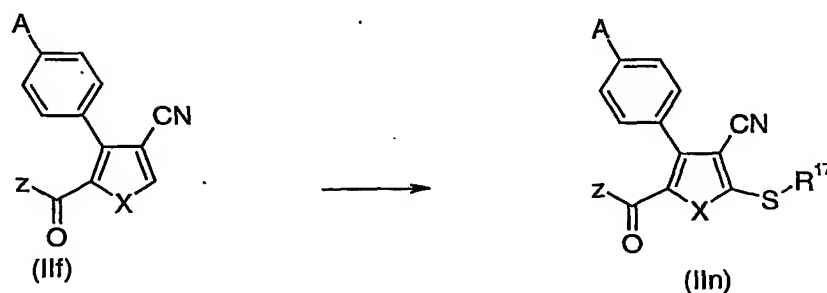
In Scheme XVI, the compound of Formula (IIj) is coupled to an aryl halide or triflate of structure (19), wherein Ar represents a suitable aryl group, under Suzuki-Type coupling reaction conditions well known to one of ordinary skill in the art to provide the compound of Formula (IIk). These Suzuki-Type coupling reaction conditions are well known to one of ordinary skill in the art. For example, see Suzuki, A., *Journal of Organometallic Chemistry*, 576, 147-168 (1999), Miyaura and Suzuki, *Chemical Reviews*, 95, 2457-2483 (1995), Ishiyama, T, et al., *J. Org. Chem.*, 60, 7508 (1995), and Ishiyama, T, et al., *Tetrahedron Lett.*, 38, 3447 (1997). More specifically, about 1.1 equivalents of the suitable aryl halide (15) or suitable aryl triflate (19) is combined with about 1.2 equivalents of bis(pinacolato)diboron, about 0.03 equivalents of a suitable catalyst, such as PdCl<sub>2</sub>(dppf) in suitable organic solvent, such as DMF, dioxane, or DMSO, and the reaction mixture is heated to about 80°C for about 1 to 4 hours with stirring. The reaction is then cooled to room temperature and about one equivalent of the compound of Formula (IIj) is added with an additional 0.3 equivalents of PdCl<sub>2</sub>(dppf) and about 5 equivalents of a suitable base, such as 2M sodium carbonate, potassium acetate, or K<sub>3</sub>PO<sub>4</sub>. The reaction mixture is then heated to about 80°C for about 1 to 18 hours, cooled to room temperature, and quenched with water. The compound of Formula (IIk) is then isolated and purified by techniques well known in the art such as those set forth in Scheme XIII above.

## Scheme XVII



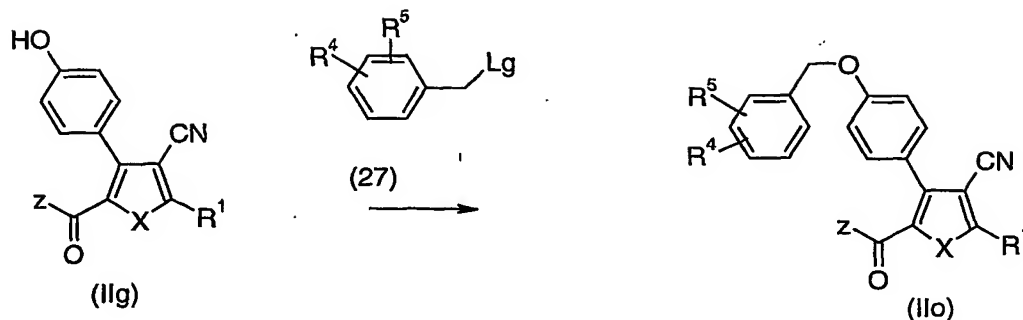
In Scheme XVII, the compound of Formula (IIIc) is coupled to a suitable aryl halide of structure (15) wherein Ar represents a suitable aryl group, in a manner analogous to the procedure set forth in Scheme (XIII) to provide the compound of Formula (Ib).

## Scheme XVIII



R<sup>17</sup> represents -(1-4C)alkyl

In Scheme XVIII, the compound of Formula (IIc) is converted to the compound of Formula (IIn) under standard conditions. For example, the compound of Formula (IIc) is dissolved in a suitable organic solvent, such as THF and cooled to about -78°C. About 1.1 equivalents of lithium bis(trimethylsilyl)amide is added and the solution is allowed to stir for about 0.5 to 1 hour. Then about 1.2 equivalents of a suitable (1-4C)alkyl disulfide is added to the reaction mixture which is allowed to warm to room temperature and stir for about about 2 to 6 hours before quenching with water. The compound of formula (IIn) is then isolated and purified by techniques well known in the art, such as extraction and chromatography.

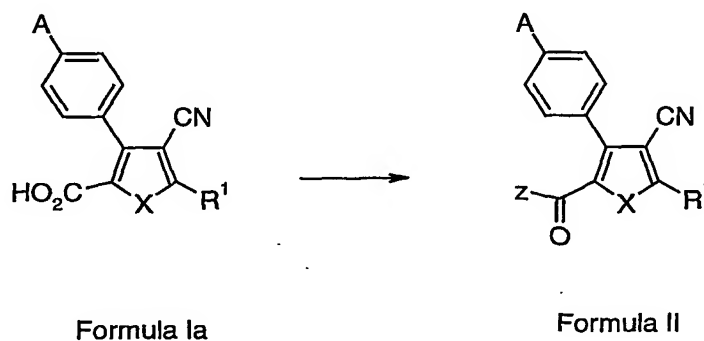
Scheme XIX

Lg represents a suitable leaving group

5

In Scheme XIX, the compound of Formula (IIg) is converted to the compound of Formula (IIo) under conditions well known in the art. For example, the compound of Formula (IIg) is dissolved in a suitable organic solvent, such as acetone and treated with about 1.2 equivalents of a compound of structure (27) wherein Lg represents a suitable leaving group, such as Br and about 1.5 equivalents of a suitable base, such as potassium carbonate. The reaction mixture is allowed to stir at room temperature for about 8 to 24 hours. The product is then isolated and purified by techniques well known in the art. For example, the reaction mixture is concentrated under vacuum and the residue is purified by flash chromatography on silica gel with a suitable eluent to provide the purified compound of formula (IIo).

15

Scheme XX

Formula Ia

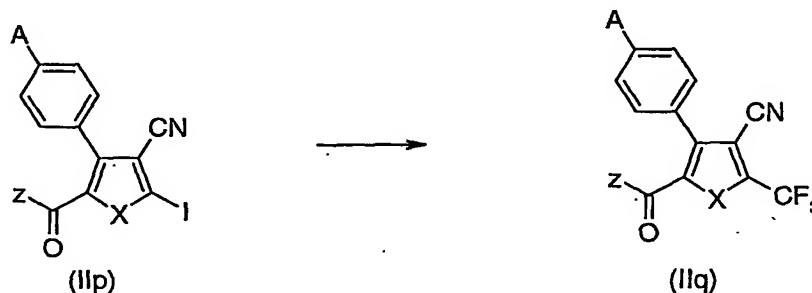
Formula II

In Scheme XX, the compound of Formula (Ia) is readily converted to the compound of Formula (II) under esterification or amidation conditions well known in the art. See for

20

example Theodora Greene, "Protective Groups in Organic Synthesis," John Wiley & Sons, Inc, pages 154-184 and pages 249-265, (1981). More specifically, for example, the compound of Formula (Ia) is dissolved in a suitable organic solvent and treated with a suitable acid, such as hydrochloric acid. Examples of suitable organic solvents include, methyl alcohol, ethyl alcohol, propyl alcohol, isopropyl alcohol, n-butyl alcohol, isobutyl alcohol, t-butyl alcohol, pentyl alcohol, isopentyl alcohol, hexyl alcohol, 3-methylpentyl alcohol, 2-ethylbutyl alcohol, and the like. The reaction is heated at about 30°C to about 60°C for about 1 hour to about 16 hours. The product is then isolated and purified using techniques well known to one of ordinary skill in the art, such as extraction techniques and chromatography. For example, the above reaction is cooled, diluted with a suitable organic solvent, such as ethyl acetate, washed with saturated sodium bicarbonate, brine, dried over anhydrous magnesium sulfate, filtered and concentrated under vacuum to provide the compound of Formula (II). This material may be further purified by flash chromatography on silica gel with a suitable eluent such as ethyl acetate/hexane.

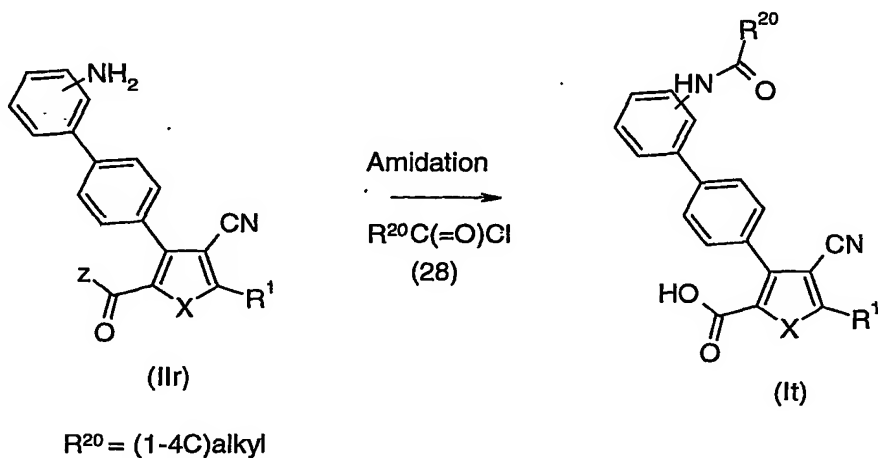
Alternatively, the compound of Formula (Ia) is dissolved in a suitable organic solvent and treated with an excess of thionyl chloride. Examples of suitable organic solvents are anhydrous methyl alcohol, ethyl alcohol, propyl alcohol, isopropyl alcohol, butyl alcohol, isobutyl alcohol, t-butyl alcohol, pentyl alcohol, isopentyl alcohol, hexyl alcohol, 3-methylpentyl alcohol, 2-ethylbutyl alcohol, and the like. The solution is stirred at reflux for about 1 to 3 hours, and at room temperature for about 8 to 16 hours. The mixture is then concentrated under vacuum, and the residue is purified in a manner analogous to the procedures described above to provide the compound of Formula (II).

Scheme XXI



In Scheme XXI, the compound of Formula (IIp) is converted to the compound of Formula (IIq) under standard conditions wherein a trifluoromethyl group replaces the iodo functionality. For example, see Chen and Wu, *J. Chem. Soc., Chem. Comm.*, 1989, page 705 for general synthetic techniques. More specifically, the compound of Formula (IIp) is combined with a catalytic amount of copper iodide or copper bromide, such as about 0.2 equivalents of copper bromide, and about 2 equivalents of methyl 2,2-difluoro-2-(fluorosulfonyl)acetate in a suitable organic solvent, such as DMF or DMSO. The reaction mixture is heated at reflux for about 30 minutes to about 6 hours and the resulting compound of Formula (IIq) is isolated and purified by techniques well known in the art. For example, the reaction mixture is diluted with water and extracted with a suitable organic solvent, such as ethyl acetate. The organic extracts are combined, dried over anhydrous sodium sulfate, filtered, and concentrated under vacuum to provide the crude material. This material can then be purified by radial chromatography on silica gel with a suitable eluent, such as ethyl acetate:hexanes to provide the purified compound of Formula (IIq).

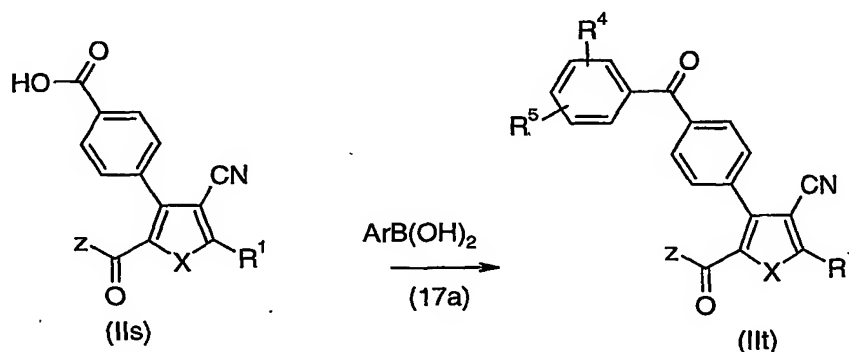
### Scheme XXII



In Scheme XXII, the compound of Formula (IIr) is amidated under conditions well known in the art to provide the compound of Formula It. For example, the compound of Formula (IIr) is dissolved in a suitable organic solvent, such as THF and treated with about 3 equivalents of a suitable base, such as triethylamine, and about 1.1 to 1.4 equivalents of the acid chloride of structure (28), such as acetyl chloride, propionyl

chloride, butyryl chloride, isobutyryl chloride, and the like. The reaction mixture is stirred at room temperature for about 2 to 8 hours. The resulting compound of Formula (It) is then isolated and purified by techniques well known in the art, such as extraction and chromatography. For example, the reaction mixture is poured into water and  
 5 extracted with a suitable organic solvent, such as ethyl acetate. The organic extracts are combined, washed with water, brine, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum. The crude residue is then purified by flash chromatography on silica gel with a suitable eluent, such as ethyl acetate:hexanes to provide the compound of Formula (It).

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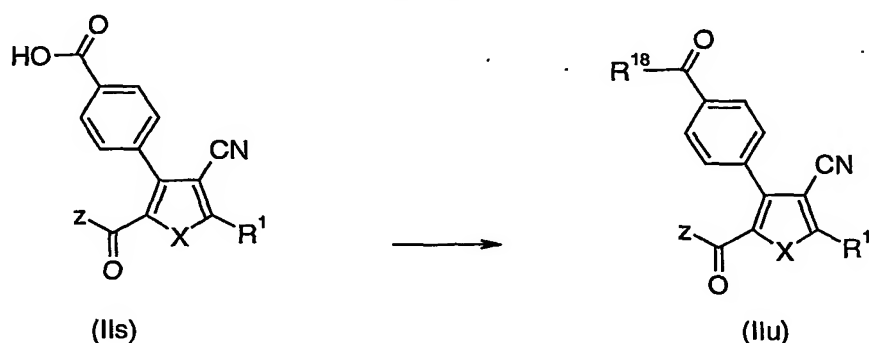
Scheme XXIII

In Scheme XXIII the carboxylic acid of the compound of formula (IIs) is converted to the ketone of the compound of formula (IIIt) under conditions well known in  
 15 the art. For example, the carboxylic acid of the compound of formula (IIs) is dissolved in a suitable organic solvent, such as THF and treated with about 1.1 to 1.3 equivalents of oxalyl chloride. To this solution is added a catalytic amount of DMF and the reaction is stirred at room temperature for about 2 hours. The reaction mixture is then concentrated under vacuum to provide the corresponding acid chloride. This acid chloride is then  
 20 dissolved in THF and added to a stirring mixture of about 1.2 equivalents of the suitable boronic acid (17a), a catalytic amount of a suitable palladium catalyst, such as tetrakis(triphenylphosphine)-palladium(0), and a suitable base, such as cesium carbonate in a suitable organic solvent, such as toluene. The reaction mixture is then heated at reflux for about 12 to 24 hours, cooled, and poured into water.

25 The resulting ketone of the compound of formula (IIIt) is then isolated and purified by techniques well known in the art, such as extraction and chromatography. For

example, the reaction mixture is poured into water and extracted with a suitable organic solvent, such as ethyl acetate. The organic extracts are combined, washed with water, brine, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum. The crude residue is then purified by flash chromatography on silica gel with a suitable eluent, such as ethyl acetate:hexanes to provide the compound of formula (II<sub>t</sub>).

Scheme XXIV



R<sup>18</sup> represents (1-4C)alkyl

In Scheme XXIV the compound of formula (II<sub>s</sub>) is converted to the ketone of the compound of formula (II<sub>u</sub>) under conditions well known in the art. For example, the compound of formula (II<sub>s</sub>) is dissolved in a suitable organic solvent, such as THF and treated with about 1.1 to 1.3 equivalents of oxalyl chloride. To this solution is added a catalytic amount of DMF and the reaction is stirred at room temperature for about 2 hours. The reaction mixture is then concentrated under vacuum to provide the corresponding acid chloride. This acid chloride is then dissolved in a suitable organic solvent, such as THF and added to about 0.14 equivalents of copper cyanide, about 0.14 equivalents lithium bromide, and about 1.4 equivalents of a zinc reagent of formula R<sup>18</sup>ZnBr in THF at about -30°C with stirring. The reaction mixture is allowed to warm to room temperature and stir for about 4 hours, and poured into water.

The resulting ketone of the compound of formula (II<sub>u</sub>) is then isolated and purified by techniques well known in the art, such as extraction and chromatography. For example, the reaction mixture is poured into water and extracted with a suitable organic solvent, such as ethyl acetate. The organic extracts are combined, washed with water, brine, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum. The crude residue is then purified by flash chromatography on silica gel with a suitable

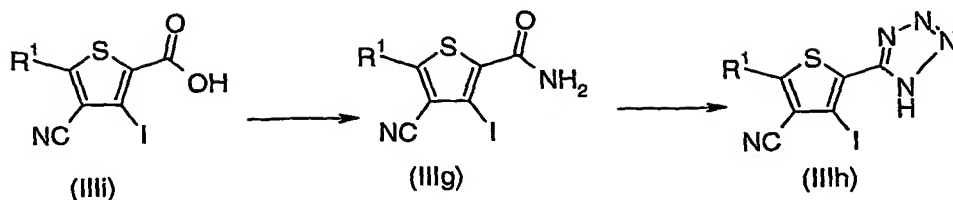
eluent, such as ethyl acetate:hexanes to provide the amide of the compound of formula (Ilu).

Scheme XXV



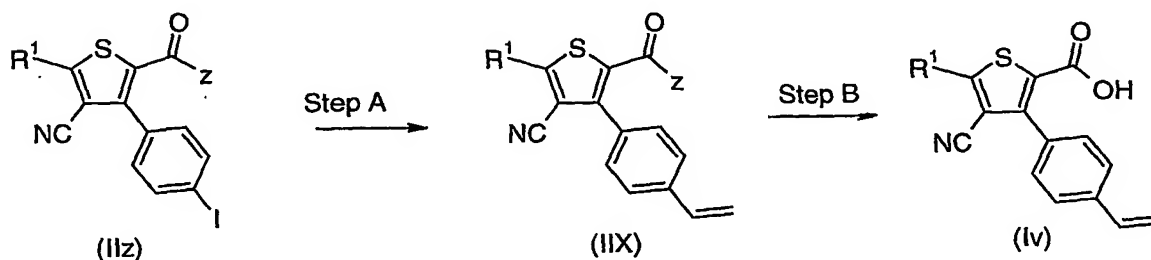
R<sup>19</sup> represents (1-4C)alkyl.

In Scheme XXV, the compound of formula (Ia) is converted to the sulfonamide of the compound of formula (Iv) under conditions well known in the art. For example, the compound of formula (Ia) is dissolved in a suitable organic solvent, such as dichloromethane followed by addition of about 1.1 equivalents of a suitable base, such as N,N-dimethylaminopyridine and about 1.2 equivalents of EDCI. To this stirring mixture at room temperature is added about 1.1 equivalents of the sulfonamide of structure (14), R<sup>19</sup>SO<sub>2</sub>NH<sub>2</sub>, and the reaction mixture is allowed to stir for about 3 to 18 hours. The resulting sulfonamide of the compound of formula (Iv) is then isolated and purified by one of ordinary skill in the art using extraction techniques and chromatography. For example, the reaction mixture is poured into 1N HCl and extracted with a suitable organic solvent, such as dichloromethane. The organic extracts are combined, washed with water and brine, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum. The crude residue is then purified by flash chromatography on silica gel with a suitable eluent, such as dichloromethane:methanol to provide the purified sulfonamide of the compound of formula (Iv).

Scheme XXVI

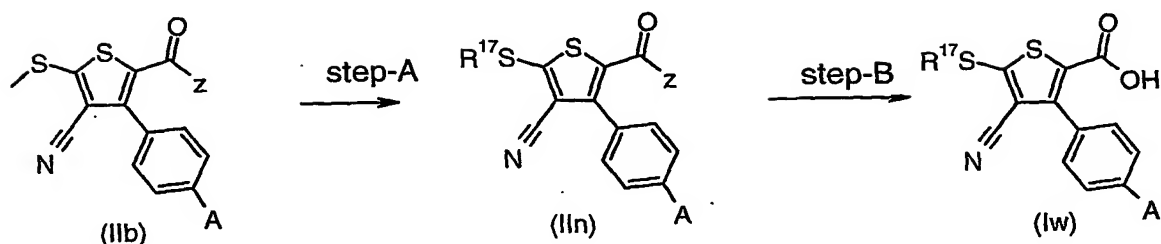
In Scheme XXVI, the compounds of formula (IIIh) can be prepared by methods previously described in Scheme XI.

5

Scheme XXVII

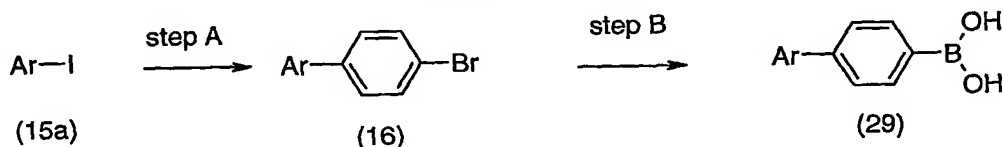
In Scheme XXVII, step A, the compound of formula (IIx) can be prepared by methods known in the art. For example, the compound of formula (IIz) is dissolved in an appropriate solvent such as tetrahydrofuran and the appropriate catalyst is added in about a 1% ratio to the starting material. Approximate one equivalent of the appropriate coupling reagent such as tributyl vinyl stannane is added along with an appropriate base such as lithium chloride. The reaction is allowed to react overnight and is then isolated and purified by one of ordinary skill in the art using extraction techniques and chromatography. For example, the reaction mixture is concentrated to dryness, washed with hexane to remove excess of stannane, added water and filtered the precipitate to provide the compound of formula (IIx). The ester of compound of formula (IIx) is hydrolyzed by methods in Scheme IX to give the compound of formula (IV).

20

Scheme XXVIII

$R^{17} = (1-4C)alkyl$

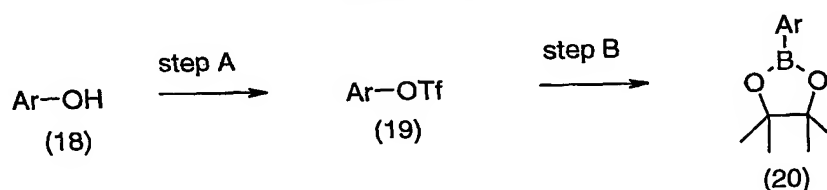
In Scheme XXVIII, step A, the compound of formula (IIIn) can be prepared by methods known in the art. For example, the compound of formula (IIb) is dissolved in an appropriate solvent such as toluene and the appropriate base such as sodium tertbutoxide is added in about 1 to 1.5 equivalent, an appropriate catalyst in a catalytic amount such as tetrakis(triphenylphosphine)-palladium(0) is added along with an appropriate ligand such as (R)-(+)-2,2'-bis(diphenylphosphino)-1,1'-binaphthyl. The suitable alkylating agent for example, ethanethiol, propanethiol, isopropylthio is added in about 2 equivalents. The reaction mixture is heated to about 90°C under nitrogen, filtered over celite, and the solvent is removed by vacuum. This material can be purified by methods known in the art such as silica gel chromatography using a solvent system such as hexane and ethyl acetate to give the final compound of formula (IIIn). The ester of compound of formula (IIIn) is hydrolyzed by methods in Scheme IX to give the compound of formula (Iw).

Scheme XXIX

In Scheme XXIX, step A, the compound of structure (16) can be prepared by methods described previously in Scheme (XIII). In Scheme XXIX, step B, the compound of structure (16) is dissolved in an appropriate solvent such as anhydrous tetrahydrofuran and cooled to about -110 °C. A solution of about 1.6 M n-butyllithium is added via a cannula while maintaining the temperature to about -95 °C. A suitable trialkylborate is added, such as trimethyl borate is added to the anion and the temperature of reaction is returned to room temperature over a period of about two hours. The borate ester is

hydrolyzed with an acid such as hydrochloride acid. The product is then isolated and purified by techniques well known in the art, such as extraction and chromatography. For example, the aqueous phase is extracted with a suitable organic solvent, such as dichloromethane, the organic extracts are combined, washed with brine, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum to provide the crude compound of structure (29). The crude boronic acid is dissolved in an appropriate base such as aqueous sodium hydroxide and washed with ethyl ether. The aqueous solution is cooled to about 0 °C and acidified with an acid such as hydrochloric acid. The crude product of formula (29) is extracted with a suitable organic solvent, such as dichloromethane, the organic extracts are combined, dried over anhydrous magnesium sulfate, filtered, and concentrated under vacuum to provide the compound of structure (29). For example, 2'-carbonitrile-biphenyl-boronic acid can be synthesized by using the starting materials 2-iodobenzonitrile and 4-bromophenylboronic acid.

Scheme XXX



In Scheme XXX step A, the phenol of structure (18) is dissolved in a suitable solvent such as methylene chloride or tetrahydrofuran and cooled to about -20 °C to about -70 °C. A base such as pyridine or sodium hydride is added and the anion is allowed to form for about an hour. The triflate group is added by the reagent trifluoromethanesulfonic anhydride or depending on other substituents of the compound of structure (18), N-phenyltrifluoromethanesulphonimide might be considered. The reaction is allowed to proceed at room temperature for about 90 minutes to overnight. The reaction can be quenched with 1N hydrochloric acid or evaporated to dryness. The crude material is isolated by extracting the aqueous layer with a suitable solvent such as methylene chloride or diethylether. The organic phase is washed with water, saturated sodium bicarbonate, optional saturated sodium chloride, drying over sodium sulfate or magnesium sulfate. The crude material can be used further without purification or can be

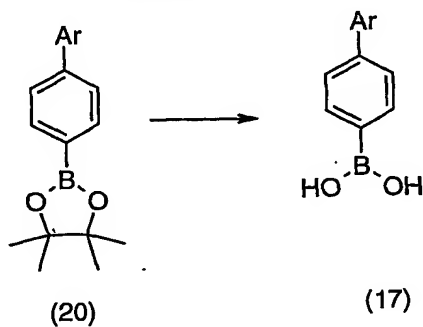
purified by silica gel chromatography using an eluent such as ethyl acetate/hexane to give the compound of structure (19).

In Scheme XXX, Step B, compounds of structure (20) are prepared essentially the same as in Scheme XXIX using the trifluoro-methanesulfonic acid 4-cyclopentylphenyl ester instead of the iodo compound and extracting with methylene chloride.

An alternative method might be used if substituents of the aromatic ring would not be appropriate to conditions described in Scheme (XXX) step (A) would include the use of the palladium catalyst  $\text{PdCl}_2$  (dppf) and the base potassium acetate, and the solvent dimethylformamide.

For example, 2-(4-cyclopentyl-phenyl)-4,4,5,5-tetramethyl-[1,3,2]dioxaborlane can be synthesized by this method using the starting materials 4-cyclopentyl phenol and trifluoromethanesulfonic anhydride and the base pyridine. Also, 3-[4,4,5,5-tetramethyl-[1,3,2]dioxaborlane-2-yl]-phenyl-propionitrile can be prepared from 3-(4-hydroxy-phenyl)-propionitrile.

Scheme XXXI



In Scheme XXXI, the compound of structure (20) is oxidized by using methods well known in the art. For example, the compound of structure (20) is dissolved in an appropriate solvent such as acetone and an oxidizing agent such as sodium periodate. A ammonium acetate solution is also added. The reaction is also stirred at room temperature for about twenty hours. The product is then isolated and purified by techniques well known in the art, such as the reaction mixture is filtered, concentrated under vacuum, aqueous layer extracted with a suitable solvent such as methylene chloride, organic layers combined, dried over sodium sulfate, and concentrated under vacuum to give the crude compound of structure (17). To the crude compound of structure (17),



hexanes and tert-butylmethyl ether can be added to the crude product until a solid is formed. The solid can be isolated by filtration to give pure compounds of structure (17).

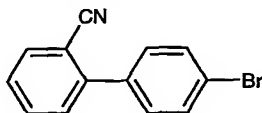
The examples set forth herein represent typical syntheses of the compounds of the present invention. The following examples have been labeled as follows for ease of reference: "Example E-1" refers for example to compounds wherein  $R^2$  represents an ester group; "Example A-1" refers for example to compounds wherein  $R^2$  is a carboxylic acid group; "Example AM-1" refers for example to compounds wherein  $R^2$  is an amide group; "Example CN-1" refers for example to compounds wherein  $R^2$  is a cyano group; "Example S-1" refers for example to compounds wherein  $R^2$  is a sulfonamide group; and "Example T-1" refers for example to compounds wherein  $R^2$  is a triazole or tetrazole group. The reagents and starting materials are readily available to one of ordinary skill in the art.

As used herein, the terms listed in the following table have the corresponding meanings as indicated:

Term	Meaning
Ex.	Example
MS(FIA)	Flow injection analysis mass spectrometry
MS(FD)	Field distortion mass spectrometry
MS(IS)	Ion spray mass spectrometry
MS(FAB)	Fast atom bombardment mass spectrometry
MS(ES)	Electron spray mass spectrometry
HRMS	High resolution mass spectrometry
$^1\text{H}$ NMR	Proton nuclear magnetic resonance spectrometry
eq.	equivalents
g	grams
mg	milligrams
L	liters
mL	milliliters
$\mu\text{L}$	microliters
mol	moles

Term	Meaning
mmol	millimoles
psi	pounds per square inch
m.p.	melting point
DSC	differential scanning calorimetry
J/g	joules per gram
min	minutes
h or hr	hours
°C	degrees celsius
TLC	thin layer chromatography
HPLC	high performance liquid chromatography
R <sub>f</sub>	retention factor
R <sub>t</sub>	retention time
δ	parts per million down-field from tetramethylsilane
aq.	aqueous
Celite®	diatomaceous earth filtering agent
HMPA	hexamethylphosphoramide
RT	room temperature
DMF	N,N-dimethylformamide
DMSO	methyl sulfoxide
LDA	lithium diisopropylamide
EtOAc	ethyl acetate
THF	tetrahydrofuran
iPrOAc	isopropyl acetate
HOBt	1-hydroxybenzotriazole
methyl DAST	dimethylaminosulfur trifluoride
DMAP	dimethylaminopyridine
DAST	diethylaminosulfur trifluoride
TFA	trifluoroacetic acid
MTBE	tert-butyl methyl ether

Term	Meaning
DBU	1,8-diazabicyclo[5.4.0]undec-7-ene
TEA	triethylamine
TBDMS	tert-butyldimethylsilyl
NBS	N-bromosuccinimide
Et <sub>3</sub> N	triethylamine
(Boc) <sub>2</sub> O	di-tert-butyl dicarbonate
DME	1,2-dimethoxyethane
EtOH	ethanol
MeOH	methanol
Triflate	-SO <sub>3</sub> CF <sub>3</sub> functional group
(dppf)	1,1'-bis(diphenylphosphino)ferrocene
S.M.	starting material
DCC	dicyclohexylcarbodiimide
Pd <sub>2</sub> (dba) <sub>3</sub>	tris(dibenzylideneacetone)-dipalladium(0)
EDCI	1-ethyl-3-[3-(dimethylamino)propyl]-carbodiimide HCl
SELECTFLUOR®	1-chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane bis-(tetrafluoroborate)
DIAD	Diisopropyl azodicarboxylate
OTf	-OS(O) <sub>2</sub> CF <sub>3</sub> ,

Preparation 14'-Bromo-biphenyl-2-carbonitrile

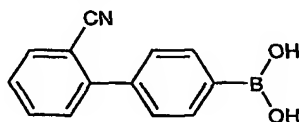
- 5           Combine 2-iodobenzonitrile (9.0g, 38.5 mmol), 4-bromophenylboronic acid (10.4g, 51.8 mmol), 2M aqueous sodium carbonate (20 mL) and tetrakis(triphenylphosphine)- palladium(0) ( 4.5g, 3.9 mmol) in 300 mL of dioxane and heat to 80°C under nitrogen with stirring. After 3 hours cool to room temperature and dilute with 900 mL of ethyl acetate. Wash with water (2 x 50mL), brine (1 x 50mL) and
- 10       dry over sodium sulfate. Filter and evaporate to a yellow solid. Chromatograph on silica

gel two times, eluting with a gradient of 100% toluene to 1/9 ethyl acetate/toluene to give the title compound as a tan solid, 5.42 g (55%). MS (FAB) = 257 ( $M^+$ ); HPLC analysis is 95%.

5

### Preparation 2

#### 2'-Carbonitrile-biphenyl-boronic acid



10

Dissolve 4'-bromo-biphenyl-2-carbonitrile (2.0g, 7.8 mmol) in 40 mL of ethyl acetate and dry over magnesium sulfate. Filter off drying agent and evaporate; dissolve the dried starting material in 100mL of anhydrous tetrahydrofuran and cool to  $-100^{\circ}\text{C}$ . Next add dropwise via cannula a solution of 1.6M n-butyllithium in hexanes (5.9mL, 9.4 mmol), keeping the internal temperature less than  $-95^{\circ}\text{C}$ . After 5 minutes, add anhydrous trimethyl borate (1.6mL, 14.0 mmol) in one portion to the yellow-orange solution of the anion and allow the resulting mixture to come to room temperature over two hours. Next adding 40 mL of 5N hydrochloric acid hydrolyzes the borate ester and extract the boronic acid with methylene chloride (3 x 100mL). Wash the combined organic layers with brine (1 x 50mL), dry over magnesium sulfate, filter and evaporate. Dissolve the crude boronic acid in 100 mL of 1N aqueous sodium hydroxide and wash with ethyl ether (2 x 50mL) to remove the non-acidic impurities. Cool the washed aqueous layer to  $0^{\circ}\text{C}$  and acidify with 100mL of 5N aqueous hydrochloric acid. Extract the product with methylene chloride (3 x 100mL), dry organic layer over magnesium sulfate, filter, and evaporate to give the title compound, 1.22g (71%) as a white solid: MS: (ES-, m/e) = 222 ( $M^+-1$ ); HPLC = 75%.

15

20

### Preparation 2A

#### Alternative preparation of 2'-Carbonitrile-biphenyl-boronic acid

#### 2-Bromofluoren-9-one

25

30

Add acetic acid (2.34 L), sulfuric acid (52.96 g), water (778.49 mL), and 9-Fluorenone (2.16 moles; 389.24 g, to a 5 L 3-neck reaction flask equipped with a thermocouple, heating mantle, overhead stirrer, and addition funnel. Heat to  $49-51^{\circ}\text{C}$ .

Add bromine (2.16 moles; 111 mL; 345 g) to addition funnel. Begin dropwise addition of bromine. Continue heating at 51°C for 22.5 hrs. Add an additional bromine (109 g, 0.68 moles) to the addition funnel and began dropwise addition. Continue heating at 51°C for an additional 1 hour then warm reaction mixture to 58°C and continue heating. Turn off  
5 heat after 36 hours from beginning the addition of bromine. Cool the reaction mixture to ambient temperature and stir for about 12 hours.

Recover the precipitate by vacuum filtration using a neoprene dam. Rinse the filter cake three times with a mixture of acetic acid (0.193 L) and water (0.156 L). Rinse the filter cake three times with water (0.35 L). Vacuum dry the filter cake at 50°C and 15-25 mm.

10 This affords the title compound 2-bromofluoren-9-one (386.7 grams, 69 % yield): <sup>1</sup>H NMR (CDCl<sub>3</sub>, 500.0 MHz): δ 7.81 (d, 1H, J=2.0); 7.70 (dt, 1H, J=7.5, 1); 7.65 (dd, 1H, J=8, 2); 7.56-7.54 (m, 2H); 7.44 (d, 1H, J=7.5); 7.37-7.35(m, 1H).

4'-Bromo- [1,1'-Biphenyl]-2-carboxylic acid

15 Add potassium *t*-butoxide (1.89 moles; 212.54 g) and tetrahydrofuran (1.81 L) to a 5L 3-neck flask equipped with an overhead stirrer, cooling bath, thermocouple, addition funnel, and nitrogen inlet. Stir to obtain a solution. Add 2-bromofluoren-9-one (0.582 moles; 151.00 g). Add ice-water to bath. Add water (0.87 moles; 15.8 g) dropwise.

Cool the mixture from 32 °C to 17°C using the ice-water bath. Add 5.0N hydrochloric  
20 acid (2.48 moles; 0.495L) while limiting the temperature to less than 38°C. Add water (0.50 L) and stir until a clear biphasic solution is observed. Add heptane (0.525 L) and separate the phases. Discard the aqueous phase. Concentrate the organic phase by vacuum distillation and add heptane (0.70 L). Warm the mixture to reflux at 75-77 °C and remove the distillate until the vapor temperature reaches 73°C. Cool the mixture to

25 29°C and recover the precipitate by vacuum filtration. Rinse the filter cake three times with heptane (75 mL). Vacuum dry the solids overnight at 50 °C and 15-20 mm. This affords the title compound (130.6 grams) in 81% yield: <sup>1</sup>H NMR (CDCl<sub>3</sub>, 500.0 MHz): δ 7.96 (dd, 1H, J=1.5, 8); 7.55 (td, 1H, J=1.5, 7.5); 7.50 (app. d, 2H, J=9); 7.43 (td, 1H, J=1, 8); 7.31 (dd, 1H, J=1.5, 8); 7.18 (app. d, 2H, J=9).

4'-Bromo-2-biphenylcarboxamide

Add toluene, 0.510L, 4'-bromo- [1,1'-Biphenyl]-2-carboxylic acid, (0. 613 moles 170.00 g), and dimethylformamide (0.89grams) to a 3 L 3-neck reaction flask equipped  
5 with a heating mantle, thermocouple, overhead stirrer, addition funnel, condenser, and nitrogen inlet. Add thionyl chloride (0.92 moles; 109.48 grams) to the addition funnel. Warm the mixture to 37 °C while stirring. Add thionyl chloride dropwise and continue heating and stirring at 37 °C until the reaction mixture clarifies. Distill 25 ml out of the reaction mixture and cool to 16°C.

10 Set up 5L 4 neck flask equipped with an ice bath, thermocouple, overhead stirrer, cannula, condenser, and gas inlet tube.

Add concentrated ammonium hydroxide (200 mL) and toluene, (0.510 L) to a 5L 4-neck flask equipped with an ice bath, thermocouple, overhead stirrer, cannula, condenser, and gas inlet tube. Cool the mixture of ammonium hydroxide and toluene to 1°C. Transfer the  
15 contents of the 3L flask to the 5 L flask acid via cannula with rapid stirring and cooling, thereby limiting the temperature to < 46°C. Cool the resulting suspension to 20°C and recover the precipitate by vacuum filtration. Rinse the filter cake with methyl *t*-butyl ether (200 mL), then rinse the filter cake three times with water (350 mL). Vacuum dry the solids at 50°C and 15-20 mm to afford the dry weight of product = 160.8 g of the final  
20 compound in 95% yield: <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 500.0 MHz): δ 7.72 (br. s, 1H); 7.62 (app. d, 2H, J=8); 7.53-7.42 (m, 3H); 7.39 (dt, 1H, J=1, 8); 7.34 (br. s, 1H).

4-Bromo-2'-cyanobiphenyl

25 Add a water wet filter cake containing 4'-bromo-2-biphenylcarboxamide, (410.8 grams total, containing 114 grams of water and of 4'-bromo-2-biphenylcarboxamide, (297 grams, 1.075 moles) and toluene (2.20 L) to a 5 L three neck reaction flask equipped with heating mantle, thermocouple, overhead stirrer, Dean-Stark trap and condenser. Stir the mixture and began heating for azeotropic removal of water at atmospheric pressure.  
30 Distillation is observed with pot temp of 85°C. Distill out 114 g water while pot temp increased to 108°C. Discontinue heating and allow the mixture to cool to 79°C. Add 2.0 L acetonitrile and triethylamine (2.36 moles: 239.28 grams). Remove the Dean-Stark trap

and add an addition funnel to the 5 L flask. Place an ice-water bath under flask. Cool the mixture to 17°C. Add trifluoroacetic anhydride (1.18 moles; 248.33 grams) to the addition funnel. Begin addition of trifluoroacetic anhydride as a steady stream over about 7 minutes, controlling temperature from 28 to 35 °C during the addition. Maintain > 30 °C after the addition is complete. Filter the mixture to clarify the solution if desired. Return one half of the filtrate to 5L reaction flask and add water (0.50 L). Transfer the biphasic solution to a separatory funnel and allow the phases to separate. Drain the lower phase and extract the upper phase with water (0.175 L). Drain the lower phase and combine the lower phases. Retain the combined lower phases and retain the upper phase separately. Transfer the remainder of the filtrate to the 5L reaction flask and add water (0.50 L). Transfer the resulting mixture to a separatory funnel, and allow the phases to separate. Remove the lower phase and combine with the retained lower phase from above in a separatory funnel and extract with toluene (0.10 L). Remove the lower phase and discard. Combine the upper phases and concentrate by vacuum distillation at 15-20 mm to 727 grams of suspension. Transfer the suspension back to the 5 L reaction flask and warm to 80°C. Add heptane (1L) and warm further until distillation is observed. Continue distillation until separation of a lower aqueous phase in the distillate is no longer observed. Discontinue heating and add additional heptane (0.484 L) and cool the mixture to 25°C. Recover the precipitate by vacuum filtration. Rinse the filter cake twice with heptane (0.20 L); Vacuum dry the solid at 40°C to afford the title compound (268 grams) in 96.5% yield: <sup>1</sup>H NMR (CDCl<sub>3</sub>, 500.0 MHz): δ 7.75 (app. d, 1H, J=8); 7.64 (td, 1H, J=1.5, 7.5); 7.61 (app. d, 2H, J=8.5); 7.5-7.4 (m, 4H).

#### 2-Cyano-4'-biphenylboronic acid

Add tetrahydrofuran (0.53 L) to a 5 L 3-neck flask equipped with an overhead stirrer, thermocouple, addition funnel, nitrogen inlet, and cooling bath. Purge the apparatus with nitrogen. Cool the tetrahydrofuran to -12 °C using a dry-ice/ acetone bath. Add via cannula to the addition funnel isopropylmagnesium chloride 2.0 M solution in tetrahydrofuran (0.447 moles; 223.74 mL) to the addition funnel. Add isopropylmagnesium chloride 2.0 M solution in tetrahydrofuran to THF with stirring. Add to addition funnel via cannula *n*-Butyl Lithium 1.6 M solution in hexanes (0.813 moles; 0.509 L). Add the contents of the addition funnel to the 5L reaction flask over

-76-

about 28 minutes while observing a temperature increase to -3 °C. Stir at 0 to -5 °C for about 1 hour. Cool the mixture to -55 °C and stir for about 1.5 hours.

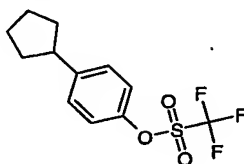
Add 2-cyano-4'-biphenylboronic acid (0.407 moles; 105.00 grams) and

tetrahydrofuran (0.77 L) to a 1-L single neck round bottom flask. Purge the flask with

- 5 nitrogen. Connect 1 L flask to an addition funnel on the 5 L flask above. Transfer the 2-cyano-4'-biphenylboronic acid solution to the addition funnel via a cannula. Add of 2-cyano-4'-biphenylboronic acid solution to contents of the 5- L flask lithium over about 45 minutes while maintaining -54 to -50 °C during the addition. Cool to -70 to 78°C. Add trimethyl borate (1.42 moles; 0.162 L) to addition funnel, and rapidly add to the 5 L
- 10 reaction flask. Observe a temperature increase to about -35°C. Add hydrochloric acid 5.0N solution in water (0.447 L). Transfer the mixture to a separatory funnel and allow the phases to separate. Remove the lower phase and transfer to a second addition funnel. Extract the lower phase three times with methyl-*t*-butyl ether (0.250 L). Remove and discard the lower phase after the third extraction. Combine these extracts with the
- 15 upper organic phase. Extract the combined upper phases twice with water (0.25 L). Remove and discard the lower phase. Concentrate the upper phase by vacuum distillation at 15-20 mm to 172 grams. Transfer the resulting residue to a 5 L 3 neck flask with acetone (0.12 L). Stir the resulting suspension until a solid phase is observed, then slowly pour water (0.50 L into the suspension. Stir at 20 to 30 °C for about 18 hours. Recover
- 20 the solid by filtration and rinse the filter cake with water (150 mL). Again rinse the resulting cake with water (0.20 L), while stirring the cake on the filter. Vacuum the filter cake at 50°C to afford the title compound (69.0 grams) in 76% yield: <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>, 500.0 MHz): δ 8.21 (s, 2H); 7.98 (dd, 1H, J=1.5, 8); 7.95 (d, 2H, J=8); 7.82 (dt, 1H, J=1.5, 7.5); 7.66 (d, 1H, J=7); 7.61 (dt, 1H, J=1, 8); 7.57 (d, 2H, J=8). Note: The NMR
- 25 spectrum may be more complex due to the formation of boroxine complexes.

### Preparation 3

#### Trifluoro-methanesulfonic acid 4-cyclopentyl-phenyl ester

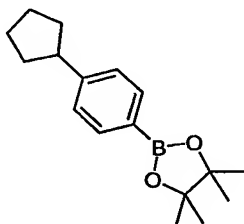




Add dry pyridine (1.4 mL, 17.3 mmol) to a solution of 4-cyclopentyl-phenol (1.0g, 5.86 mmol) in 35 mL of  $\text{CH}_2\text{Cl}_2$  and cool to  $-70^\circ\text{C}$  under nitrogen. Add trifluoromethanesulfonic anhydride (1.2 mL, 7.13 mmol) dropwise and remove the cooling bath and allow the reaction to warm to room temperature. Ninety minutes later pour the mixture into 50 mL cold 1N HCl. Shake and separate the layers; wash with organics with ice-water (1x20 mL) and saturated aqueous  $\text{NaHCO}_3$  (1x20mL) and dry over  $\text{Na}_2\text{SO}_4$ . Filter and evaporate to a brown oil, 1.8 g, which is used without further purification.

#### Preparation 4

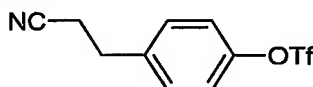
##### 2-(4-Cyclopentyl-phenyl)-4,4,5,5-tetramethyl-[1,3,2]dioxaborolane



Prepare the title compound in a manner analogous to the procedure set forth in 4-cyano-5-ethyl-3-[4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-thiophene-2-carboxylic acid ethyl ester using the crude trifluoromethanesulfonic acid 4-cyclopentyl-phenyl ester (5.86 mmol), refluxing for 4 hours and extracting with  $\text{CH}_2\text{Cl}_2$  instead of EtOAc. Yield = 1.8g dark red oil which is used without further purification.

#### Preparation 5

##### Trifluoromethanesulfonic acid 4-(2-cyano-ethyl)-phenyl ester

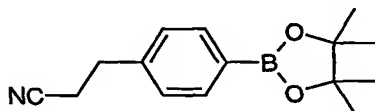


Add NaH 95% (90 mg, 3.74 mmol) to a  $-20^\circ\text{C}$  solution of 3-(4-hydroxy-phenyl)-propionitrile or 4-cyclopentylphenol (commercially available) (3.4 mmol) in dry THF (25 ml) under nitrogen atmosphere and stir at this temperature for 1 hour. Add N-phenyltrifluoromethanesulfonylimide (commercially available) (3.74 mmol, 1.1 eq) in one portion and stir overnight at room temperature. Evaporate solvents to dryness and partition the crude between diethyl ether and water. Wash the organic phase with sodium carbonate 10% solution and NaCl sat. solution, dry over  $\text{MgSO}_4$  and remove the solvent

in vacuo. Purification by flash chromatography (hexane:ethyl acetate, 4:1) to provide the title compound.

#### Preparation 6

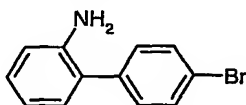
##### 3-[4-(4,4,5,5-Tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-propionitrile



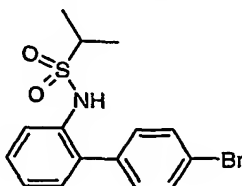
Heat at 80°C a mixture trifluoro-acetic acid 4-(2-cyano-ethyl)-phenyl ester (2.63 mmol), PdCl<sub>2</sub>(dppf) (0.5 mmol, 0.2 eq), bis(pinacolato)diboron (commercially available) (3.156 mmol, 1.2 eq) and potassium acetate (774 mg, 7.89 mmol, 3 eq) in DMF (16 ml) under nitrogen atmosphere overnight. Partition the reaction mixture between ethyl acetate and ice-water. Wash the organic phase with HCl 10% solution and water, dry over MgSO<sub>4</sub> and filter over Celite® and remove the solvent in vacuo. Purification by flash chromatography (hexane: ethyl acetate 4:1) to provide the title compound.

#### Preparation 7

##### 4'-Bromo-biphenyl-2-ylamine



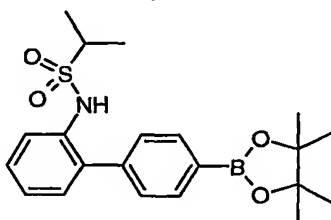
Add 4-bromophenyl boronic acid (5.0 g, 24.82 mmol), tetrakis(triphenylphosphine) palladium (0) (0.717 g, 0.620 mmol) and 2 M Na<sub>2</sub>CO<sub>3</sub> (10 mL) to a solution of 2-iodoaniline (4.5 g, 20.69 mmol) in toluene (2 mL):ethanol (20 mL), degas and heat at 80 °C under nitrogen. After 4 h, add water and extract with ethyl acetate. Combine the organic layers, dry over sodium sulfate, filter and concentrate under reduced pressure to give a residue. Purify the residue by flash chromatography (silica gel) eluting with ethyl acetate:hexane 1:12 to provide the title compound (3.53 g, 69 %): Mass spectrum (m/e): 248 (M+1); 249 (M+2). <sup>1</sup>HNMR (CDCl<sub>3</sub>) δ 3.62 (s, 2 H); 6.75-6.89 (m, 2 H); 7.08-7.18 (m, 2 H); 7.21-7.40 (m, 2 H); 7.55-7.63 (m, 2 H).

Preparation 8Propane-2-sulfonic acid (4'-Bromo-biphenyl-2-yl)-amide

- 5 Add dropwise 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) drop wise (8.76 mL, 56.92 mmol) to a solution of 4'-bromo-biphenyl-2-ylamine (3.53 g, 14.23 mmol) in dichloromethane (50ml) at 0°C, followed by drop wise addition of isopropylsulfonyl chloride (3.29 mL, 28.46 mmol) and stir the reaction at room temperature for 24 h. Remove solvent under reduce pressure and purify the residue by silica and eluting with
- 10 ethyl acetate:hexane 1:4 to ethyl acetate to provide the title compound (4.93 g, 98%): Mass spectrum (m/e): 355 (M+1); 353 (M-1); <sup>1</sup>HNMR (CDCl<sub>3</sub>) δ 1.24 (d, 6 H, J = 6.7 Hz); 3.28 (sep, 1 H, J = 6.9 Hz); 6.22 (s, 1 H); 7.12-7.41 (m, 5 H); 7.55-7.68 (m, 3 H).

Preparation 9

- 15 Propane-2-sulfonic acid (4'-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-biphenyl-2-yl)-amide



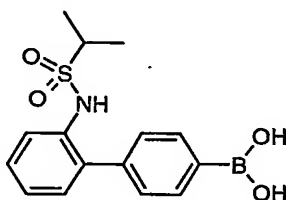
- Heat at 80 °C a mixture of propane-2-sulfonic acid (4'-bromo-biphenyl-2-yl)-amide (4.0 g, 11.22 mmol), bis(pinacolato)diboron (3.22 g, 12.34 mmol), [1,1'-bis(diphenylphosphino)ferrocene]-dichloropalladium(II) complex with dichloromethane (1:1) (0.276 g, 0.337 mmol) and potassium acetate (3.32 g, 33.87 mmol) in dry dimethyl sulfoxide (25 mL). After 16 h add water and extract with ethyl acetate. Combine organic layers, dry over sodium sulfate and evaporate under reduce pressure. Dissolve the residue in dichloromethane and wash with a solution of 0.1N HCl. Combine the organic layers,
- 20
- 25 dry over sodium sulfate, filter and concentrate under reduced pressure. Purify the residue

by flash chromatography (silica gel) eluting with ethyl acetate:hexane 1:3 to provide the title compound (4.07 g, 90%): Mass spectrum (m/e): 424 (M+23); 400 (M-1); <sup>1</sup>HNMR (CDCl<sub>3</sub>) δ 1.19 (d, 6 H, J = 6.7 Hz); 1.37 (s, 12 H); 3.19 (sep, 1 H, J = 6.9 Hz); 6.38 (s, 1 H); 7.16-7.39 (m, 6 H); 7.61-7.72 (m, 1 H); 7.64-7.94 (m, 1 H).

5

#### Preparation 10

##### Propane-2-sulfonic acid (4'-(boronic acid)-biphenyl-2-yl)-amide

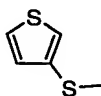


Add sodium periodate (1.12 g, 5.25 mmol) followed by a solution of 1 N ammonium acetate (8 mL) to a suspension of propane-2-sulfonic acid [4'-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-biphenyl-2-yl)-amide (0.7 g, 1.75 mmol) in acetone (16 mL)/water (0.8 mL). Stir the mixture at room temperature under nitrogen for 20 h. Filter the precipitate and evaporate organic layer. Extract aqueous layer with dichloromethane. Combine organic layers, dry over sodium sulfate and evaporate the solvent under reduced pressure. Add hexanes and tert-butylmethyl ether to the residue until a solid is formed and filter the solid to provide the title compound (0.37 g, 67%). Mass spectrum (m/e): 337 (M+18); 318 (M-1); <sup>1</sup>HNMR (CDCl<sub>3</sub>) δ 1.22 (d, 6 H, J = 6.7 Hz); 3.24 (sep, 1 H, J = 6.9 Hz); 6.46 (s, 1 H); 7.18-7.89 (m, 6 H); 8.38-8.42 (m, 1 H).

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#### Preparation 12

##### 3-Methylsulfanyl-thiophene



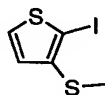
Add dropwise a solution of *n*-BuLi (63.2 ml, 1.6 M) to a solution of 3-bromothiophene (15 g, 92 mmol) in hexane (135 ml) at -40°C. Add THF (45 ml) to the flask and the 3-lithiothiophene precipitates as a white solid. Add more hexane (45 ml) and warm the reaction mixture to room temperature. Add dropwise methyl disulfide (9.1 ml, 101.2 mmol) to the resulting solution and stir the reaction mixture for 12 hours at room

25

temperature. Add water (approx. 100 mL) to the flask, separate the organic layer, dry with magnesium sulphate and evaporate the solvent to yield 13 g (95 %) of the title compound as a colorless oil.

### Preparation 13

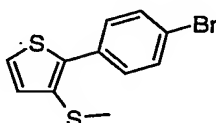
#### 2-Iodo-3-methylsulfanyl-thiophene



Add dropwise a solution of bis (pyridine) iodonium (I) tetrafluoroborate (46 g, 123 mmol, see J. Org. Chem., 55, 3104, (1990) in dichloromethane (500 ml) to a solution of 3-methylsulfanyl-thiophene (16 g, 123 mmol) in dichloromethane (300 ml) at room temperature. After 10 minutes add water, separate the organic layer, dry with magnesium sulphate and evaporate the solvent. Dissolve the crude product in ethyl acetate (200 ml) and wash with a solution of NaHSO<sub>3</sub> 10 % (3 x 100 ml). Separate the organic layer, dry with magnesium sulphate and evaporate the solvent to yield 23 g (74 %) of the title compound as a slightly colored oil.

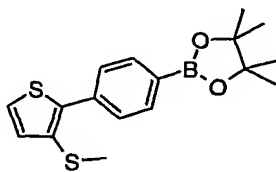
### Preparation 14

#### 3-Methylsulfanyl-2-phenyl-thiophene



Degas a solution of 2-iodo-3-methylsulfanyl-thiophene (18 g, 70.3 mmol), 4-bromobenzeneboronic acid (14.1 g, 70.3 mmol), potassium carbonate (21.4 g, 155 mmol), tetrakis(triphenylphosphine)-palladium (0) (8.1 g, 7.02 mmol) in a mixture of anhydrous dimethoxyethane (300 ml) and absolute ethanol (150 ml) with Ar or N<sub>2</sub> for 15 min and stir for 12 hours at 80°C. Cool the reaction mixture to room temperature, add water (100 ml) and extract the crude product with dichloromethane (3 x 150ml). Purify the title compound by column chromatography using hexane as eluent solvent to yield the title compound 12 g (60 %) as a white solid.

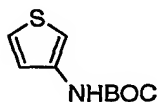
**NOTE:** This product is also light sensitive and it is highly recommended to be used immediately. We have observed decomposition of aprox 5% of the material after 12 hours.

Preparation 154,4,5,5-Tetramethyl-2-[4-(3-methylsulfanyl-thiophen-2-yl)-phenyl]-[1,3,2]dioxaborolane

Combine 3-methylsulfanyl-2-phenyl-thiophene (12 g, 42 mmol),

- 5 bis(pinacolato)diboron (11.8 g, 46.2 mmol), potassium acetate (13.6 g, 138.9 mmol), PdCl<sub>2</sub>(dppf) (3.42 g, 4.2 mmol) in anhydrous DMSO (150 ml) and stir at 80°C for 12 hours. Cool the reaction mixture to room temperature, dilute with ethyl acetate (200 ml), and wash with water (3 x 100 ml). Separate the organic layer and dry with magnesium sulphate. To this solution, add 10 g of silica and evaporate the solvent. Place the resulting
- 10 mixture in a sintered glass funnel and elute with a 10:1 mixture of Hexane/EtOAc. The catalyst remains in the silica. Evaporate the solvent and obtain the solid which was disgregated with hexane (to eliminate most of the bis(pinacolato)diboron which is the major impurity) to yield 6 g (50 %) of the title compound.

15

Preparation 16Thiophen-3-yl-carbamic acid tert-butyl ester

- Using the method of Barker (Barker, J. M.; Huddleston, P. R.; Wood, M. L. *Synthetic Communications* **1995**, 25(23), 3729-3734) reflux methyl-3-aminothiophene-2-carboxylate (42.8 g, 0.27 mol) at 120°C with 2M sodium hydroxide aqueous solution (270
- 20 mL) for 30 min. Cool the reaction mixture to 0°C and acidify to pH 5.0 (Congo red) with concentrated hydrochloric acid. Filter the thick precipitate and dry the solid. Dissolve the solid in acetone (300 mL) and dry (MgSO<sub>4</sub>) the resulting solution, filter, and evaporate at 20°C. Perform as soon as possible because the acid decomposes quite rapidly (≈ 1 hour
- 25 the solid turns black). Treat the resulting thick oil with oxalic acid dihydrate (26.7 g) in 2-propanol (100 mL) at 38°C for 45 min. Allow the mixture to reach room temperature, dilute with ether (40 mL), filter the solid, and wash with ether. Exposure to light and air, the resulting white solid (33.1 g) became pale lilac. Dissolve the resulting salt (33.1 g) in

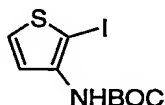
water (400 mL) and basify with concentrated  $\text{NH}_3$ . Upon exposure to light and air, the salt is more stable than the acid and it is possible to keep it in a brown bottle under argon or nitrogen atmosphere for approx. 2 days. Extract the mixture with dichloromethane (3 x 200 mL) and combine the extracts, dry over  $\text{MgSO}_4$ , and evaporate to give a brown oil  
5 (15 g, 56%).

Dissolve 3-aminothiophene (15 g, 0.15 mol) in dichloromethane (300 mL) and add  $\text{Et}_3\text{N}$  (42.2 mL, 0.3 mol) at  $0^\circ\text{C}$ . Add a solution of  $(\text{Boc})_2\text{O}$  (39.3 g, 0.18 mol) in methylene chloride (100 mL) dropwise at  $0^\circ\text{C}$  and stir the mixture overnight at r.t.. T.L.C.

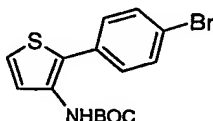
10 (Hexane/Ethyl acetate 9:1) shows complete disappearance of starting material. Quench the reaction by addition of water (200 mL). Extract the mixture with dichloromethane (2 x 200 mL), combine the extracts, dry over  $\text{MgSO}_4$  and evaporate. Purification by flash chromatography (Silica gel –Hexane /ethyl acetate 9:1) gives 20.1 g (67%) of title compound as a white solid.

#### Preparation 17

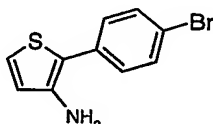
##### (2-Iodo-thiophen-3-yl)-carbamic acid tert-butyl ester



Using the method of Monroe *et. al.* (Campaigne, E.; Monroe, P. A. *J.A.C.S.* **1954**,  
20 76, 2447-2450) add to a boiling solution of thiophen-3-yl-carbamic acid tert-butyl ester (21.0 g, 0.1 mol) in dichloromethane (400 mL) NIS (23.7 g, 0.1 mol) in small portions. Heat the reaction with the heating bath at  $65^\circ\text{C}$  for 20 min. Checking by T.L.C. (Hexane/ethyl acetate 9:1) shows complete consumption of starting material. Take the reaction to room temperature, evaporate the solvent and purification by flash  
25 chromatography (Silica gel–Hexane /ethyl acetate 9:1) of the crude to obtain 30.0 g (88%) of title compound as a white solid.

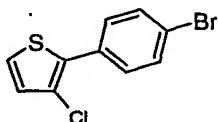
Preparation 18[2-(4-Bromo-phenyl)-thiophen-3-yl]-carbamic acid tert-butyl ester

Heat (2-iodo-thiophen-3-yl)-carbamic acid tert-butyl ester (16.88 g, 0.52 mol), 4-bromophenylboronic acid (15.65 g, 0.78 mol),  $\text{Na}_2\text{CO}_3$  (1.01 g, 1.04 mol) and  $\text{Pd}(\text{PPh}_3)_4$  (5.79 g, 0.052 mol) in 375 ml of an anhydrous and deoxygenated 2:1 DME/EtOH mixture to 80°C under nitrogen atmosphere for 24h. Analysis by T.L.C. (Hexane/Ethyl acetate 9:1) shows complete disappearance of starting material. Evaporate the organic solvents, prior to the addition of water (200 mL). Extract the mixture with dichloromethane (3 x 150 mL) and dry the combined organic phases ( $\text{MgSO}_4$ ) and concentrate to furnish a crude mixture as a yellowish solid. Purification by flash chromatography (Silica gel-Hexane /Ethyl acetate 49:1) yielded 10.8 g (60%) of title compound as a pale yellow solid.

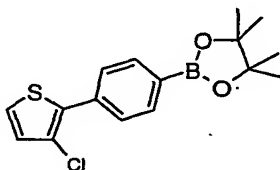
Preparation 192-(4-Bromo-phenyl)-thiophen-3-yl amine

Treat a solution of [2-(4-bromo-phenyl)-thiophen-3-yl]-carbamic acid tert-butyl ester (10.8 g, 0.3 mol) in ethyl acetate (75 mL) at 0°C, dropwise with 244 mL (8mL/mmol) of freshly prepared 1N HCl in ethyl acetate and stir the mixture at r.t. overnight. Dissolve the white precipitate with  $\text{H}_2\text{O}$  (100 mL) and neutralize with a  $\text{NaHCO}_3$  saturated solution. Extract the mixture with ethyl acetate (3 x 100 mL) and dry the combined organics and concentrate to give a slightly colored solid. Purification by flash chromatography (Silica gel-Hexane /ethyl acetate 49:1 then 9:1) furnishes 5.7 g (74%, at 1.0 g scale, the reaction was quantitative) of title compound as a pale yellow solid.

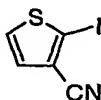


Preparation 222-(4-Bromo-phenyl)-3-chloro-thiophene

- 5        Add dropwise a solution of 2-(4-bromo-phenyl)-thiophen-3-yl amine (1.0 g, 3.94 mmol) in dry acetonitrile (7 mL) to a mixture of t-BuONO (1.87 mL, 15.76 mmol) and CuCl<sub>2</sub> (1.06 g, 7.87 mmol) in dry acetonitrile (15 mL) at 0°C. Stir the reaction for 2h. Analysis by T.L.C. (Hexane) shows complete consumption of starting material. Add water (20 mL) and extract the mixture with ethyl acetate (2 x 20 mL). Combine the organic
- 10    layers and dry and concentrate to give a crude solid. Purification by flash chromatography (Silica gel-Hexane) gives 0.75 g (70%) of the title compound as a pale yellow oil.

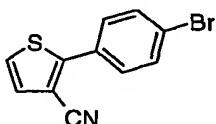
Preparation 232-[4-(3-Chloro-thiophen-2-yl)-phenyl]-4,4,5,5-tetramethyl-[1,3,2]dioxabrolane

- 15        Deoxygenate by purging with nitrogen a mixture of 2-(4-bromo-phenyl)-3-chloro-thiophene (1.0 g, 3.66 mmol), bis(pinacolato)diboron (1.39 g, 5.48 mmol), KOAc (1.18 g, 12.08 mmol) and Pd(dppf)<sub>2</sub>Cl<sub>2</sub> catalyst (0.3 g, 0.37 mmol) in dry DMF (20mL) and heat at 80°C overnight. Analysis by T.L.C. (Hexane/ethyl acetate 4:1) shows complete
- 20    consumption of starting material. Add water (20 mL) and extract with ether (3 x 20 mL). Wash the combined organic with water and dry and concentrate to give a crude solid. Purification by flash chromatography (Silica gel-Hexane /ethyl acetate 99:1) gives pure 1.05 g (89%) of the title compound as a pale yellow solid.

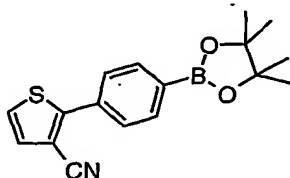
Preparation 242-Iodo-thiophene-3-carbonitrile

Add dropwise to a solution of diisopropylamine (32.1 mL, 229 mmol) in THF (1 L) at  $-40^{\circ}\text{C}$  *n*-BuLi (143 mL, 229 mmol) and stir for 30 minutes. Cool the reaction mixture to  $-78^{\circ}\text{C}$  and add 3-cyanothiophene (25 g, 229 mmol). After stirring for 15 minutes, add a solution of N-iodosuccinimide (52 g, 229 mmol) in THF (250 mL) and warm the reaction mixture to room temperature. Add water (approx. 200 mL) to the flask, separate the organic layer, dry with magnesium sulphate and evaporate the solvent.

Purification by column chromatography (hexane-methyltertbutyl ether 100/1) to yield 20 g (40 %) as a white solid:  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  7.10 (d,  $J = 5.6$  Hz, 1H), 7.47 (d,  $J = 5.6$  Hz, 1H).  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  87.1, 115.8, 120.8, 130.6, 133.

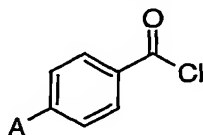
Preparation 252-(4-Bromo-phenyl)-thiophene-3-carbonitrile

Degass a solution of 2-iodo-thiophene-3-carbonitrile (20 g, 85 mmol), 4-bromobenzenboronic acid (18.8 g, 94 mmol), potassium carbonate (26 g, 187 mmol) and tetrakis(triphenylphosphine)-palladium (0) (10g, 8.5 mmol) in a mixture of anhydrous dimethoxyethane (300 mL) and absolute ethanol (150 mL) with Ar or  $\text{N}_2$  for 15 min and stir for 12 hours at  $80^{\circ}\text{C}$ . Cool the reaction mixture to room temperature, add water (100 mL) and extract the crude product dichloromethane (3 x 150 mL). Purification by chromatography (hexane-ethyl acetate 10/1) to yield 16.3 g (72.%) as a white solid:  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  7.32 (m, 2H), 7.62 (m, 4H).

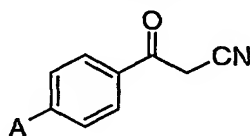
Preparation 262-[4-(4,4,5,5-Tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-thiophene-3-carbonitrile

Stir a solution of 2-(4-bromo-phenyl)-thiophene-3-carbonitrile (16.3 g, 62 mmol),  
5 bis(pinacolato)diboron (17.2 g, 68 mmol), potassium acetate (20 g, 204 mmol),  
PdCl<sub>2</sub>(dppf) (5 g, 6.1 mmol) in anhydrous DMSO (200 mL) at 80°C for 12 hours. Cool  
the reaction mixture to room temperature, dilute with ethyl acetate (250 mL), and wash  
with water (3 x 100 mL). Separate the organic layer and dry with magnesium sulphate and  
10 evaporate the solvent. Purify the crude product by column chromatography using a  
mixture of hexane ethyl acetate (8/1) of eluent solvent to provide the title compound: <sup>1</sup>H  
NMR (CDCl<sub>3</sub>): δ 1.37 (s, 12H), 7.32 (m, 2H), 7.76 (d, *J* = 8.3 Hz, 2H). 7.91 (d, *J* = 8.3  
Hz, 2H); <sup>13</sup>C NMR (CDCl<sub>3</sub>): δ 25.2, 84.5, 106.8, 116.1, 126.2, 127.3, 131.0, 134.1, 135.9,  
154.0.

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General Preparation 274-A-Benzoyl chloride

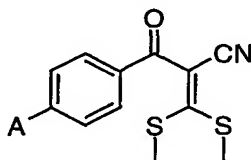
Dissolve 4-A-benzoic acid (wherein A is defined wherein) (7.0 mmol) in thionyl  
chloride (1.0 ml) and heat at 50°C. After 1 hour, remove solvent in vacuo to give 1.63 g  
20 (quantitative) of title compound which is used without further purification in next steps.

General Preparation 283-Oxo-3-(4-A-phenyl)-propionitrile

Add butyllithium (1.6 M in hexane) (28 mmol) to a stirring solution of cyanoacetic acid (14 mmol) (dry previously with  $\text{MgSO}_4$  in ethyl acetate) in THF (80 ml) and cool at  $-78^\circ\text{C}$  under a nitrogen atmosphere. Allow the reaction temperature to slowly rise to  $0^\circ\text{C}$ . Recool the slurry to  $-78^\circ\text{C}$  and add dropwise a solution of 4-A-benzoyl chloride, prepared in general preparation 27, (7.0 mmol) in 10 ml of THF and stir at  $-78^\circ\text{C}$ . After 1 hour, allow the reaction mixture to gradually come to room temperature over a period of 1 hour. Add HCl (1N solution) and extract with ethyl acetate. Wash organic phase with  $\text{NaHCO}_3$ , sat. NaCl, dry over  $\text{MgSO}_4$  and remove solvent in vacuo. Purification by chromatography (hexane: ethyl acetate mixture) to provide the title compound

#### General Preparation 29

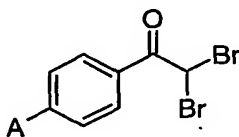
##### 2-(4-A-benzoyl)-3,3-bis-methylsulfanyl-acrylonitrile



Add in two portions NaH 95% (7.63 mmol) to a stirring solution of 3-oxo-3-(4-A-phenyl)-propionitrile, prepared in general preparation 28, (3.47 mmol) and  $\text{CS}_2$  (3.47 mmol) in 10 ml of DMSO at  $15^\circ\text{C}$  under nitrogen atmosphere. Gradually, warm to room temperature. After 2 hours, add iodomethane (6.94 mmol) (dropwise) and stir for 1 h. Add the crude reaction over ice-water mixture and extract with ethyl acetate. Wash organic phase with sat. NaCl, dry over  $\text{MgSO}_4$ , and remove solvent in vacuo. Purification by chromatography (hexane: ethyl acetate mixture) to provide the title compound.

#### General Preparation 30

##### 2,2-Dibromo-1-(4-A-phenyl)-ethanone



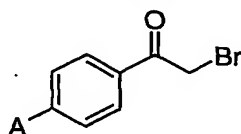
Dissolve 4-A-acetophenone, wherein A is defined herein, (4.9 mmol) in concentrated sulfuric acid (1 ml) and cool the resulting solution to  $0^\circ\text{C}$ . Add, dropwise,

bromine (4.9 mmol), warm to room temperature, and stir for 6 hours. Pour the reaction mixture into ice-water and a solid precipitates. Collect the solid by filtration, wash with water, and air-dry to afford the title compound.

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### General Preparation 31

#### 2-Bromo-1-(4-A-phenyl)-ethanone



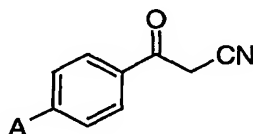
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Add diethylphosphite (4.87 mmol), triethylamine (4.87 mmol) to a solution of 2,2-dibromo-1-(4-A-phenyl)-ethanone, prepared in general preparation 30, (4.63 mmol) in THF (7 m) at 0°C. Warm to room temperature and stir. After 6 hours, pour the reaction mixture into ice-water and a solid crash out. Collect the solid by filtration, wash with water, and air-dry to afford the title compound.

15

### General Preparation 32

#### 3-(4-A-phenyl)-3-oxo-propionitrile



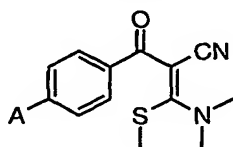
20

Stir 2-bromo-1-(4-A-phenyl)-ethanone, prepared in preparation 31, (1.99 mmol), sodium cyanide (2.19 mmol, 1.1 eq) in acetonitrile (6 ml) at room temperature for 2 days. Dissolve the reaction in ethyl acetate, wash with NaCl sat. solution, water, dry over MgSO<sub>4</sub> and filter. Remove the solvent in vacuo to give 430 mg (95% yield) of title compound.

25

### General Preparation 33

#### 2-(4-A-Benzoyl)-3-dimethylamino-3-methylsulfanyl-acrylonitrile

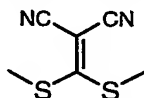


Add dimethylamine 40% aq. solution (0.49 mmol) to a mixture of 2-(4-A-benzoyl)-3,3-dimethylsulfanyl-acrylonitrile, prepared in general preparation 29, (0.49 mmol) in acetonitrile (1 ml) and stir at room temperature. After 12 hours, remove the solvents in vacuo to give title compound.

5

#### Preparation 34

##### Bis(methylthio)methylenepropanedinitrile



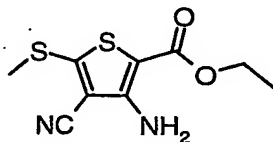
Add malononitrile (50.0 g, 757 mmol) to dry DMSO (600 mL), mechanically stir, cool to 15 °C, and place under nitrogen. Add NaH (60%, 40 g, 1.00 mol) in small portions over 25 min keeping the internal temperature <25 °C and stir mixture. After 10 min, slowly add carbon disulfide (45.5 mL, 757 mmol) over 20 min at the same temperature. Stir at room temperature for 2.5 h then add additional NaH (60%, 29.6 g, 0.74 mol) while keeping the temperature constant with external cooling. Stir for 1.5 h at rt then cool to 15 °C. Add iodomethane (103.7 mL, 1.67 mol) over 15 min. Stir resulting mixture overnight then pour into water (2.8 L). Stir the resulting dark orange precipitate for 15 min then collect by filtration, wash with water, partially air-dry, and wash with hexanes. Air-dry the tan powder to a constant weight (103 g) then recrystallize from 2-propanol. Filter solid, wash with cold 2-propanol and hexanes, then dry to afford the title compound: <sup>1</sup>H NMR (DMSO-*d*<sub>6</sub>): δ 2.78 (s, 6H); <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>): δ 186.0, 113.3, 74.2, 18.9.

15

20

#### Preparation 35

##### 3-Amino-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester



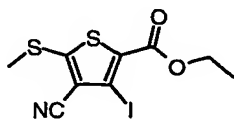
25

Stir a slurry of bis(methylthio)methylenepropanedinitrile, prepared in preparation 34, (69.29 g, 407 mmol) in ethanol (1.1 L) under nitrogen at rt then add ethyl thioglycolate (44.9 mL, 407 mmol) followed by triethylamine (56.7 mL, 407 mmol). Heat

the resulting mixture at 65 °C for 30 min. Cool slowly to 35 °C over 45 min, then cool to 3 °C over 20 min and maintain at that temperature for 20 min. Collect precipitate by filtration, wash with cold ethanol and ether to afford the title compound: <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 5.77 (bs, 2H), 4.28 (q, J = 7.1, 2H), 2.64 (s, 3H), 1.33 (t, J = 7.1, 3H); TLC (25% hexanes/ethyl acetate) R<sub>f</sub> = 0.25).

#### Preparation 36

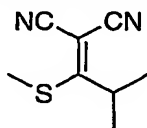
##### 4-Cyano-3-iodo-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester



**CAUTION!** Care should be taken to insure that the reaction has initiated *prior* to addition of all of the *i*-amyl nitrite as a vigorous reaction ensues with nitrogen evolution and an exotherm! Stir a slurry of ethyl 3-amino-4-cyano-5-methylthiothiophene-2-carboxylate, prepared in preparation 35, (5.00 g, 20.6 mmol) in acetonitrile (25 mL) under nitrogen then add CH<sub>2</sub>I<sub>2</sub> (582 mL, 72.2 mmol). Warm to 35 °C resulting in a dark homogenous solution, then add *i*-amyl nitrite (6.93 mL, 51.6 mmol) slowly. After addition of the nitrite, let reaction slowly cool to ambient temperature over 45 min. Cool further the resulting slurry to 5 °C and add hexanes (15 mL). Collect the resulting solid by filtration washing with acetone/hexanes (1:10), diethyl ether/hexanes (1:3), then hexanes to afford the title compound: <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 4.38 (q, J = 7.0, 2H), 2.70 (s, 3H), 1.40 (t, J = 7.0, 3H); TLC (CH<sub>2</sub>Cl<sub>2</sub>) R<sub>f</sub> = 0.5).

#### Preparation 37

##### 2-(2-Methyl-1-methylsulfanyl-propylidene)-malononitrile



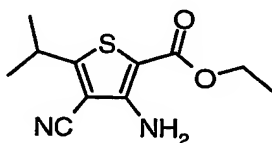
Add isopropylmagnesium chloride 2M in THF (3 ml, 6.0 mmol) to a solution of bis(methylthio)methylenepropanedinitrile, prepared in preparation 34, (1g, 5.88 mmol) in THF (58 ml) at -40°C. Stir the mixture from -40°C to room temperature overnight. Then, add NH<sub>4</sub>Cl sat. sol. To the mixture and extract with ethyl acetate. Dry organic layer over

MgSO<sub>4</sub> and remove the solvents under vacuum. Purify the compound by flash chromatography (Hex:ethyl acetate, 3:1) to give 389 mg (40% yield) of title compound: <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz): 3.32 (sep, J= 6.8 Hz, 1H); 2.83 (s, 3H); 1.28 (d, J= 6.9 Hz, 6H).

5

#### Preparation 37a

##### 3-Amino-4-cyano-5-isopropyl-thiophene-2-carboxylic acid ethyl ester

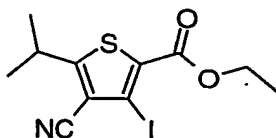


Following the procedure set forth in preparation 35, using 2-(2-methyl-1-methylsulfanyl-propylidene)-malononitrile, prepared in preparation 37, obtains the title compound. MS (ES<sup>+</sup>, m/e): 239 (M+1).

10

#### Preparation 37b

##### 4-Cyano-3-iodo-5-isopropyl-thiophene-2-carboxylic acid ethyl ester



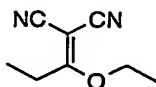
15

Following the procedure set forth in preparation 36, using 3-amino-4-cyano-5-isopropyl-thiophene-2-carboxylic acid ethyl ester, prepared in preparation 37a obtains the title compound. MS (ES<sup>+</sup>, m/e): 350 (M+1).

20

#### Preparation 38a

##### 2-(1-Ethoxy-propylidene)-malononitrile



25

Heat a mixture of triethyl orthopropionate (446 g, 2.53 mol) and malononitrile (163.9 g, 2.48 mol) at reflux under nitrogen for 1.5 h. Cool the mixture and stir overnight. Distill the dark mixture under vacuum (10-15 torr, 135-142 °C) to afford the title compound as a pale yellow oil: <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 4.40 (q, J = 7.0, 2H), 2.63, (q, J =



7.7, 2H), 1.41 (t, J = 7, 3H), 1.23 (t, J = 7.7, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ) 189.7, 113.3, 111.8, 68.3, 64.1, 25.5, 14.6, 11.3.

#### Preparation 38b

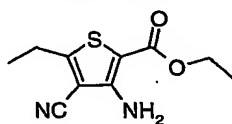
##### 5      Additional preparation of 2-(1-Ethoxy-propylidene)-malononitrile

Charge malononitrile (1.888 kg, 28.3 moles, 1.01 eq), and triethylorthopropionate (5.008 kg, 28.0 moles, 1.0eq) to a 12 L 4-neck reaction flask equipped with an overhead stirrer, heating mantle, nitrogen inlet, and condenser. Heat the reaction mixture (vigorous reflux) for 3 hours at 84°C. Allow the mixture to cool to room  
10      temperature and hold overnight. Warm the mixture and remove ethanol under reduced pressure while slowly increasing the pot temperature to 65°C. Distill ethanol until complete, increase the pot temperature to 151-160 °C and continue the distillation at 14 mm Hg, to afford 4.090 kg (97.3% yield) of title compound as a clear yellow distillate.

15

#### Preparation 39a

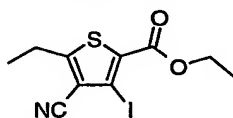
##### 3-Amino-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester



Add 2-(1-ethoxy-propylidene)-malononitrile, prepared in preparation 38, (230.0 g, 1531 mmol) in ethanol (1.3 L) stir with overhead stirring under nitrogen at rt and add  
20      ethyl thioglycolate (168.8 mL, 1531 mmol) and potassium acetate (225.4 g, 2297 mmol). Heat the resulting red mixture at 60 °C for 2 h. Add water (300 mL) and cool the mixture to 5 °C for 1 h. Collect the precipitate that forms by filtration, wash with 20-25% water/ethanol, and dry at rt for 3 d affording the title compound as light orange needles:  
25       $^1\text{H}$  NMR ( $\text{DMSO}-d_6$ )  $\delta$  6.76 (bs, 2H), 4.18 (q, J = 7.1, 2H), 2.86 (q, J = 7.5, 2H), 1.223 (t, J = 7.1, 3H), 1.220 (t, J = 7.5, 3H);  $^{13}\text{C}$  NMR ( $\text{DMSO}-d_6$ ) 163.8, 163.7, 153.7, 112.9, 100.0, 96.3, 60.0, 23.2, 14.3, 14.2.

Preparation 39bAdditional preparation of 3-Amino-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

Charge ethanol, (11.0 L), 2-(1-ethoxy-propylidene)-malononitrile, (2.003 kg, 13.34 moles, 1.0 eq), ethyl-2-mercaptoacetate (1.652 kg, 13.34 moles, 1.0 eq.), and potassium acetate (1.983 kg, 20.0 moles, 1.5 eq.) to a 22L 3-neck reaction flask equipped with an addition funnel, thermocouple, overhead stirrer, and condenser. The reaction mixture becomes dark red and exotherms to 72°C. Stir the mixture for 1.25 hours while cooling to 60 °C. Add deionized water (2.6 L) to the reaction mixture over 30 minutes while cooling to 53 °C. Cool the reaction mixture to 10°C over 3.5 hours. Filter the resulting suspension to recover the precipitate, and rinse the filter cake with a chilled mixture of 1.1 L ethanol and 3.9 L water. Vacuum the filter cake until dried at room temperature, to afford the title compound (2.552 kg) in 85.3 % yield.

Preparation 40a4-Cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester

**CAUTION!** Care should be taken to insure that the reaction has initiated *prior* to addition of all of the *i*-amyl nitrite as a vigorous reaction ensues with nitrogen evolution and an exotherm. Stir a slurry of 3-amino-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester, prepared in preparation 39, (150.0 g, 668.8 mmol) in acetonitrile (900 mL) under nitrogen then add CH<sub>2</sub>I<sub>2</sub> (188.6 mL, 2341 mmol). Warm to 45 °C resulting in a dark homogenous solution, slowly add via an addition funnel *i*-amyl nitrite (188.7 mL, 1404 mmol). After addition of about 40-50 mL of *i*-amyl nitrite, warm the reaction to 55 °C to initiate reaction. Exchange the heating mantel immediately for an ice bath to keep temperature at 60 °C and add the remaining nitrite at a rate maintaining the temperature constant. Stir for 45 min while slowly cooling to 45 °C. Concentrate the mixture *in vacuo* (ca. 15 torr, 50 °C). Take the resulting dark sludge and pass it through a plug of silica gel (1 kg; eluting with CH<sub>2</sub>Cl<sub>2</sub>). Remove the CH<sub>2</sub>Cl<sub>2</sub> *in vacuo*, mix the dark oil with 2-propanol (1 L) then hexanes (300 mL), and cool to 5 °C. Collect the resulting solid by

filtration, wash with cold 2-propanol/hexanes (3:1), and dry at ambient temperature.

Purify the solid by chromatography on silica gel (2.5 kg, eluting with 50-70%

CH<sub>2</sub>Cl<sub>2</sub>/hexanes) to provide the title compound: mass spectrum (EI<sup>+</sup>): m/z 335 (M<sup>+</sup>); <sup>1</sup>H

NMR (DMSO-*d*<sub>6</sub>) δ 4.29 (q, J = 7.1, 2H), 3.04 (q, J = 7.5, 2H), 1.29 (t, J = 7.1, 3H), 1.27

5 (t, J = 7.5, 3H); <sup>13</sup>C NMR (DMSO-*d*<sub>6</sub>) δ 165.3, 159.3, 128.8, 118.1, 114.4, 92.4, 61.7, 23.2, 14.6, 14.0.

#### Preparation 40b

##### Additional preparation of 4-Cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester

10 Charge 3-amino-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (44.9g, 0.2 moles, 1.0 eq), acetonitrile (0.9L), and diiodomethane (216.4g, 0.8 moles, 4.0 eq, filter to remove Cu stabilizer) to a 3L 3-neck reaction flask (an addition funnel, thermocouple, overhead stirrer, and Friedrich condenser). Attach a bump tank and secondary condenser to the outlet of the Friedrich condenser. Dilute Isoamyl nitrite (48.8g, 0.4 moles, 2.0 eq)

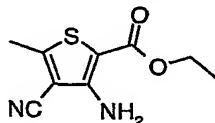
15 with heptane (45ml) and charge to the addition funnel. Inert the reaction mixture using a nitrogen sweep of the headspace for about 2 minutes. Close the reactor and set the nitrogen for by-pass through a bubbler. Warm the reaction mixture to 70°C. Add rapidly a 20 ml portion of the isoamyl nitrite-heptane solution. After 2-3 minutes initiation of the reaction occurs as evidenced by an abrupt exotherm to 77 °C and a vigorous release of

20 nitrogen. After stirring for another 2-3 minutes, cautiously add the remainder of the isoamyl nitrite-heptane solution and complete after 0.5 hrs. Control nitrogen evolution so it is complete at the end of the addition. Cool the mixture to 23° C, transfer to a rotary evaporator, and concentrate under reduced pressure to 210 g of non-volatile residue.

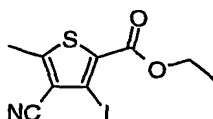
Charge SiO<sub>2</sub> (380g) to a 95cm diameter column (bed depth 110 cm). Wet the

25 silica gel with heptane. Dissolve the non-volatile residue from above in 105 ml of heptane and 105 ml of methylene chloride. Pour the solution onto the silica gel, and elute with 3.5 L heptane to remove the diiodomethane. Discard this, and elute the silica gel further with 1:1 heptane:methylene chloride. Discard the first 4.2 L, and collect the following 2.6 L, combine and remove solvent, to afford 56 g (84%) of crude product. Slurry the crude

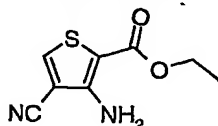
30 product in 250 ml heptane for 2 hrs, collect by filtration and vacuum dry to afford the title compound (51.3 g) in 76.5% yield.

Preparation 413-Amino-4-cyano-5-methyl-thiophene-2-carboxylic acid ethyl ester

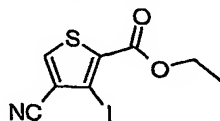
Follow the procedure set forth in preparation 39, using 2-(1-ethoxy-ethylidene)-malononitrile to prepare the title compound:  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$  5.7 (br s, 2H), 4.28 (q,  $J = 7.2$ , 2H), 2.57 (s, 3H), 1.34 (t,  $J = 7.2$ , 3H).

Preparation 424-Cyano-5-methyl-3-iodo-thiophene-2-carboxylic acid ethyl ester

Follow the procedure set forth in preparation 40, using 3-amino-4-cyano-5-methyl-thiophene-2-carboxylic acid ethyl ester, prepared in preparation 41, to prepare the title compound: (EI+):  $m/z$  322 ( $M^+ + 1$ ); MS (ES+,  $m/e$ ): 322 ( $M + 1$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$  4.38 (q,  $J = 7.05$ , 2H), 2.74 (s, 3H), 1.39 (t,  $J = 7.2$ , 3H).

Preparation 433-Amino-4-cyanothiophene-2-carboxylic acid ethyl ester

Follow the procedure set forth in preparation 39, using 2-ethoxymethylene-malononitrile to prepare the title compound: MS (ES+,  $m/e$ ): 197 ( $M + 1$ ).

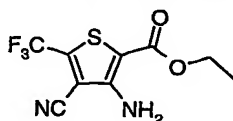
Preparation 444-Cyano-3-iodo-thiophene-2-carboxylic acid ethyl ester

Follow the procedure set forth in preparation 40, using 3-amino-4-cyanothiophene-2-carboxylic acid ethyl ester, prepared in preparation 43, to prepare the title compound: MS (ES+, m/e): 308 (M+1).

5

#### Preparation 45

##### 3-Amino-4-cyano-5-trifluoromethyl-thiophene-2-carboxylic acid ethyl ester

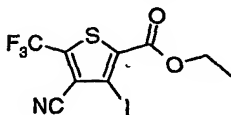


Combine 1,1-dicyano-2-chloro-2-(trifluoromethyl)ethylene (0.554 mmol) (prepared by the method of Middleton, J. Fluorine Chem., 20, 1982, p397-418) and ethanol in a 50 ml flask. Add ethyl 2-mercaptoacetate (0.554 mmol) and potassium acetate (0.831 mmol) and heat to 60-70 °C for 30-40 minutes. Cool the reaction and add water. Product crystallizes as yellowish needles. Filter crystals and wash with 1:1 ethanol / water. Dry solid under reduced pressure to give the title compound as light yellow crystals: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 5.88 (s, 2H), 4.36 (q, 2H, J=7.2 Hz), 1.38 (t, 3H, J=7.0 Hz), MS found (M-1) 262.9.

15

#### Preparation 47

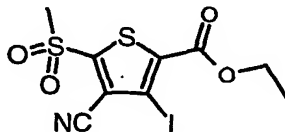
##### 4-Cyano-3-iodo-5-trifluoromethyl-thiophene-2-carboxylic acid ethyl ester



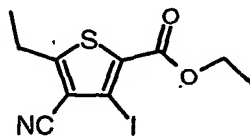
Combine 3-amino-4-cyano-5-trifluoromethyl-thiophene-2-carboxylic acid ethyl ester, prepared in preparation 45, (1.12 mmol), diiodomethane (3.92 mmol), and isoamyl nitrite (2.8 mmol) in CH<sub>3</sub>CN and heat to 80 °C. After 45 minutes, cool to room temperature and concentrate in vacuo. Purify the dark residue by flash chromatography eluting with methylene chloride. Concentration of desired fractions and recrystallization from hexanes to provide the title compound: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 4.45 (q, 2H, J=7.2 Hz) and 1.44 (t, 3H, J=7.3 Hz), <sup>19</sup>F NMR (CDCl<sub>3</sub>) δ -57.6 ppm (s).

20

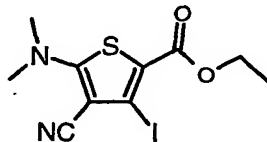
25

Preparation 484-Cyano-3-iodo-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester

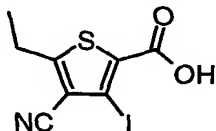
Prepare the title compound in a manner analogous to the procedure set forth in  
example E-6, 3-(4-iodophenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid  
ethyl ester, using 4-cyano-3-iodo-5-methylsulfonyl-thiophene-2-carboxylic acid ethyl  
ester, prepared in preparation 36, as the starting material: MS (ES+, m/e): 386 (M+1).

Preparation 494-Cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid ethyl ester

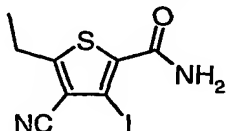
Prepare the title compound in a manner analogous to the procedure set forth in  
example E-9, 3-(4-iodophenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester,  
using 4-cyano-3-iodo-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester,  
prepared in preparation 48, as the starting material: MS (ES+, m/e): 336 (M+1).

Preparation 504-Cyano-3-iodo-5-dimethylamino-thiophene-2-carboxylic acid ethyl ester

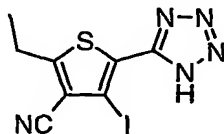
Prepare the title compound in a manner analogous to the procedure set forth in  
example E-7, 3-(4-iodophenyl)-4-cyano-5-dimethylamino-thiophene-2-carboxylic acid  
ethyl ester, using 4-cyano-3-iodo-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl  
ester, from preparation 48, as starting material: MS (ES+, m/e): 351 (M+1).

Preparation 514-Cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid

Prepare the title compound in a manner analogous to the procedure set forth in  
example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic  
acid, using 4-Cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid ethyl ester, preparation  
40 or preparation 49: MS (ES<sup>+</sup>, m/e): 262 (M-COOH).

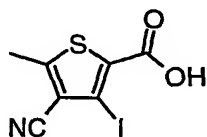
Preparation 524-Cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid amide

Prepare the title compound in a manner analogous to the procedure set forth in  
example AM-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic  
acid amide, using 4-cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid, preparation 51:  
MS (ES<sup>+</sup>, m/e): 329 (M+23).

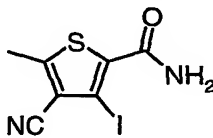
Preparation 534-Iodo-2-ethyl-5-(1H-tetrazol-5-yl)-thiophene-3-carbonitrile

Prepare the title compound in a manner analogous to the procedure set forth in  
example T-2, 4-(4-tert-butyl-phenyl)-2-methylsulfanyl-5-(1H-tetrazol-5-yl)-thiophene-3-  
carbonitrile using 4-cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid amide, prepared in  
preparation 52: MS (ES<sup>+</sup>, m/e): 330(M-1).

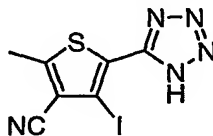
-100-

Preparation 544-Cyano-3-iodo-5-methyl-thiophene-2-carboxylic acid

Prepare the title compound in a manner analogous to the procedure set forth in preparation 51, 4-cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid, using 4-cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid ethyl ester, prepared in preparation 40 or preparation 49: MS (ES<sup>+</sup>, m/e): 294 (M+1).

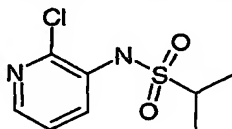
Preparation 554-Cyano-3-iodo-5-methyl-thiophene-2-carboxylic acid amide

Prepare the title compound in a manner analogous to the procedure set forth in preparation 52, 4-cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid amide using 4-cyano-3-iodo-5-methyl-thiophene-2-carboxylic acid, prepared in preparation 54: MS (ES<sup>+</sup>, m/e): 293 (M+1).

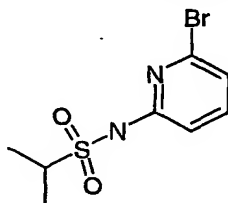
Preparation 564-Iodo-2-methyl-5-(1H-tetrazol-5-yl)-thiophene-3-carbonitrile

Prepare the title compound in a manner analogous to the procedure set forth in preparation 53, 4-iodo-2-ethyl-5-(1H-tetrazol-5-yl)-thiophene-3-carbonitrile, using 4-cyano-3-iodo-5-methyl-thiophene-2-carboxylic acid amide, prepared in preparation 55: MS (ES<sup>+</sup>, m/e): 316 (M-1).



Preparation 57Propane-2-sulfonic acid (2-chloro-pyridin-3-yl)-amide

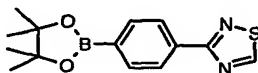
5 Prepare the title compound in a manner analogous to the procedure set forth in general example A-8 (step 1) using as starting material 2-chloro-3-aminopyridine, to provide the title compound in a 89% yield: Mass spectrum (m/e): 235 (M+1).

Preparation 58Propane-2-sulfonic acid (6-bromo-pyridin-2-yl)-amide

10

Prepare the following compound in a manner analogous to the procedure set forth in general example A-8 (step 1) using as starting material 6-bromo-2-aminopyridine, to provide the title compound as white solid: Mass spectrum (m/e): 280 (M+1).

15

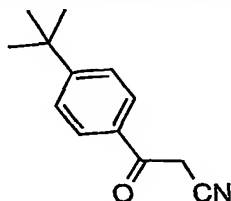
Preparation 603-[4-(4,4,5,5,-Tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-[1,2,4]thiadiazole

20 Add DMF (5 mL) to a mixture of 3-(4-bromophenyl)-[1,2,4]thiadiazole (0.241 g, 1.0 mmol), bis(pinacole)borane (0.305 g, 1.2 mmol), 1,1'-bis(diphenylphosphino)ferrocene palladium(II) dichloride (1:1) dichloromethane complex (0.089 g, 0.11 mmol) and potassium acetate (0.305 g, 3.11 mmol). Bubble with nitrogen and stir at 80°C for 2 h. Cool down and add ice-water and ethyl acetate. Separate layers and wash the organic layer with water (x3) and back-extract the combined aqueous layers with ethyl acetate (x2). Wash the combined organic layers with brine, dry over anhydrous sodium sulfate and concentrate under reduced pressure over Celite®. Purify by flash

25

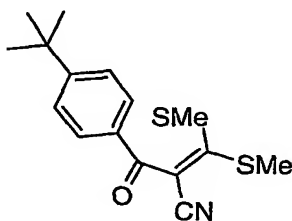
chromatography (silica gel) eluting with hexanes-ethyl acetate 10:1 first, then 5:1 to give a white solid in quantitative yield.  $^1\text{H}$  NMR:  $\delta$  9.89 (s, 1H); 8.34 (m, 2H); 7.94 (m, 2H); 1.37 (s, 12H).

5

Preparation 613-(tert-Butyl-phenyl-3-oxo-propionitrile

Add to a  $-70\text{ }^{\circ}\text{C}$  solution of cyanoacetic acid (2.55 g, 30 mmol) in THF (100 ml), n-butyl lithium (1.6 M, 37.5 ml, 60 mmol) dropwise and allow the mixture to warm up to  $0\text{ }^{\circ}\text{C}$  for 1h before it cools down again to  $-70\text{ }^{\circ}\text{C}$ . Add acid chloride (2.93, 15 mmol) to the mixture slowly and stir the mixture at  $-70\text{ }^{\circ}\text{C}$  for 1 h. Stir the reaction mixture at RT for another extra 1 h and pour into water (50 ml) and HCl (1M, 50 ml). Extract the organic with EtOAc (3x75 ml). Wash the combined organics with water (3x100 ml), brine (50 ml), dry over magnesium sulfate, filter and concentrate under reduced pressure. Purification by flash chromatography (silica gel) of the yellow residue eluting with ethyl acetate:hexanes (2: 8) to provide the desired title compound (1.8 g, 58% yield): Mass spectrum (M-1) = 200.

20

Preparation 622-(4-tert-Butyl-benzoyl)-3,3-bis-methylsulfanyl-acrylonitrile

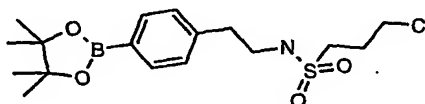
Add to a  $15\text{ }^{\circ}\text{C}$  solution of 3-(tert-Butyl-phenyl-3-oxo-propionitrile (1.8 g, 8.94 mmol), in DMSO (30 ml) carbon disulfide (0.53 ml, 8.94 mmol) and sodium hydride (0.75 mg, 18.778 mmol) and stir at RT for 2h. Cool the reaction mixture down to  $10\text{ }^{\circ}\text{C}$  before treating with methyl iodide (1.34 ml, 21.46 mmol). Stir the mixture at RT for 1h

25

and pour into water (100 ml). Extract the organic with EtOAc (3x100 ml). Combine organics, wash with water (3x100 ml), brine (50 ml), dry over magnesium sulfate, filter and concentrate under reduced pressure. Purify by flash chromatography (silica gel) the yellow crude product residue eluting with ethyl acetate:hexanes (2: 8) to provide the title compound (2.25 g, 86% yield): Mass spectrum (M-1) = 292.

### Preparation 63

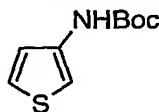
3-Chloropropane-1-sulfonic acid {2-[4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-ethyl}-amide



Add 3-chloropropanesulfonyl chloride (0.285 g, 1.6 mmol) to a suspension of 2-[4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-ethylamine (0.383 g, 1.3 mmol) in dichloromethane (10 mL) at 0°C. Slowly add DBU (0.457 g, 3.0 mmol) and allow the mixture to warm up to 23°C. Stir 2 h at 23°C and add more dichloromethane and 1M HCl. Separate layers and wash organic phase with more HCl (x2). Back-extract aqueous phase with dichloromethane (x2). Combine organic phases and wash them with brine, dry over sodium sulfate, concentrate over Celite® and purify by flash chromatography (silica gel), eluting with hexanes-ethyl acetate 3:1 to give 0.333 g of the desired compound as a thick oil. Mass spectrum ESI positive (m/z): 388 (M+1), 410 (M+23).

### Preparation 64

3-Thiophenyl-carbamic acid *tert*-butyl ester

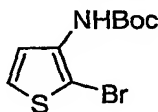


Prepare 3-aminothiophene as described in Barker, J. M.; Huddleston, P. R.; Wood, M. L. *Synthetic Communications* 1995, 25(23), 3729-3734, starting from methyl-3-amino-thiophene-2-carboxylate (42.8 g, 0.27 mol). Treat immediately the resulting thick oil with oxalic acid dihydrate (26.7 g) in 2-propanol (100 mL) at 38°C for 45 min. Cool down to room temperature and dilute with diethyl ether (40 mL). Filter the resulting solid

and wash it with diethyl ether. Dissolve the resulting salt (33.1 g) in water (400 mL) and basify with concentrated aqueous ammonia. Extract the mixture with dichloromethane (3 x 200 mL), dry the combined extracts (magnesium sulfate) and evaporate to give a brown oil (15 g, 56%). Dissolve the oil in dichloromethane (300 mL) and add triethylamine (42.2 mL, 0.3 mol) at 0°C. Then add a solution of di *tert*-butyl pirocarbonate (39.3 g, 0.18 mol) in dichloromethane (100 mL) dropwise at 0°C and stir the mixture overnight at 23°C. Add water (200 mL) and extract with dichloromethane (2 x 200 mL). Dry the combined organic extracts (magnesium sulfate) and concentrate in vacuo. Purify by flash chromatography (silica gel) eluting with hexanes /ethyl acetate 9:1 to obtain 20.1 g (67%) of the title compound as a white solid. <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ: 7.49 (m, 3H), 6.50 (br s, 1H), 1.53 (s, 9H).

#### Preparation 65

##### 2-Bromothiophen-3-yl-carbamic acid *tert*-butyl ester



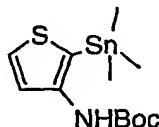
15

Add NBS (8.9 g, 0.05 mol) to a boiling solution of 3-thiophenyl-carbamic acid *tert*-butyl ester (10.0 g, 0.05 mol) in dichloromethane (500 mL) in small portions and stir the mixture at 65°C for 20 min. Cool down, remove solvent in vacuo and purify the crude material by flash chromatography (silica gel) eluting with hexanes /diethyl ether 19:1 to obtain 11.1 g (80%) as a white solid: <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ: 7.55 (br s, 1H), 7.24 (d, J = 4.0 Hz, 1H), 6.56 (br s, 1H), 1.52 (s, 9H).

20

#### Preparation 66

##### (2-Tri-*n*-butylstannyl-thiophen-3-yl)-carbamic acid *tert*-butyl ester



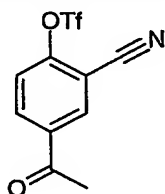
25

Add *n*-buthyl lithium (19.8 ml, 1.6 M/hexane) dropwise to a solution 2-bromothiophen-3-yl-carbamic acid *tert*-butyl ester (4 g, 14.4 mmol) in anhydrous THF (35 ml) at -78°C. Stir the mixture for 45 minutes and add trimethyltin chloride (3.16 g, 15.8

mmol). Allow the reaction mixture to reach room temperature. Add brine (aprox. 50 mL) and extract with ethyl acetate (2 x 50 mL). Dry the combined organic layers over magnesium sulfate and concentrate under vacuum to yield 4.9 g of the title compound as colorless oil:  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$ : 7.49 (d,  $J = 4.8$  Hz, 1H), 7.13 (d,  $J = 4.4$  Hz, 1H), 1.49 (s, 9H); 0.36 (s, 9H).

#### Preparation 67

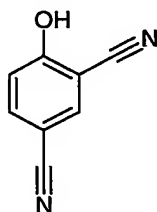
##### Trifluoro-methanesulfonic acid 4-acetyl-phenyl ester



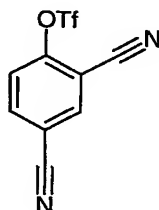
10 Add triethylamine (9.3 mmol) and DMAP (0.93 mmol) to solution of 1-(4-hydroxy-phenyl)-ethanone (commercially available) (6.2 mmol) in dry DCM (5 ml) under nitrogen atmosphere and stir at room temperature for 5 min. Then cool to  $0^\circ\text{C}$  and add slowly trifluoromethanesulfonic acid anhydride (9.3 mmol) and stir at RT overnight. Evaporate solvents to dryness and partition the crude between DCM and  $\text{NH}_4\text{Cl}$ . Dry organic phase over  $\text{MgSO}_4$  and remove the solvent in vacuo. Purification by flash chromatography (hexane:ethyl acetate, 2:1) to provide the title compound (79% yield).  
15 Mass spectrum ( $m/e$ ): 293 ( $\text{M}^+ + 1$ ).

#### Preparation 68

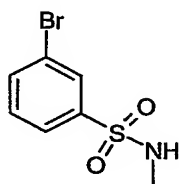
##### 4-Hydroxy-isophthalonitrile



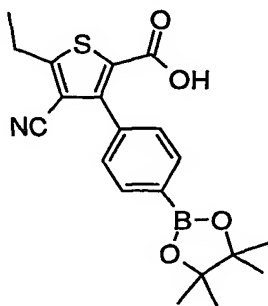
20 Add boron tribromide (15 mmol) (1M solution in DCM) to a solution of 4-methoxy-isophthalonitrile (commercially available) (10 mmol) in DCM (7 ml) at  $-78^\circ\text{C}$  and stir to RT overnight. Add water and extract with EtOAc, dry over  $\text{Na}_2\text{SO}_4$ , filter and  
25 remove the solvent in vacuo. Mass spectrum ( $m/e$ ): 143 ( $\text{M}^+ - 1$ ).

Preparation 69Trifluoro-methanesulfonic acid 2,4-dicyano-phenyl ester

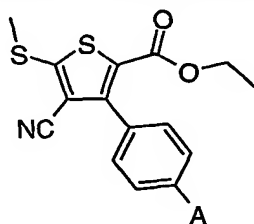
Prepare the title compound in a manner analogous to the procedure set forth in Preparation 67, using 4-hydroxy-isophthalonitrile (preparation 68) as starting material. (20% yield). Mass spectrum (m/e): 277 ( $M^+ + 1$ ).

Preparation 703-Bromo-N-methyl-benzenesulfonamide

Add 3-Bromo-benzenesulfonyl chloride (0.39 mmol) to a solution of methylamine (2M in THF) (0.39 mmol) and  $\text{Et}_3\text{N}$  (0.39 mmol) in dichloromethane (4.0 mL) and stir at RT for 24h. Partition the crude between DCM and  $\text{NH}_4\text{Cl}$ . Dry organic phase over  $\text{MgSO}_4$  and remove the solvent under reduce pressure. Triturate the crude with hexane and title compound crash out as white solid.  $^1\text{H}$ NMR ( $\text{CDCl}_3$ )  $\delta$  7.96 (m, 1H); 7.75 (dd,  $J = 1.6$  Hz,  $J = 6.8$  Hz, 1H); 7.65 (dd,  $J = 1.6$  Hz,  $J = 6.8$  Hz, 1H); 5.0 (q br., NH); 2.61 (d,  $J = 5.2$  Hz, Me).

Preparation 714-Cyano-5-ethyl-3-[4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-thiophene-2-carboxylic acid

Heat at 80°C a mixture of 3-(4-(Bromophenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid (Example A-150) (5.95 mmol), PdCl<sub>2</sub>(dppf) (0.59 mmol, 0.1 eq), bis(pinacolato)diboron (commercially available) (6.55 mmol, 1.1 eq) and potassium acetate (17.85 mmol, 3 eq) in DMF (30 ml) in a sealed tube under nitrogen atmosphere overnight. Partition the reaction mixture between ethyl acetate and ice-water. Wash the organic phase with HCl 10% solution and water, dry over MgSO<sub>4</sub> and filter over Celite® and remove the solvent in vacuo. Purification by flash chromatography over SiO<sub>2</sub> (CH<sub>2</sub>Cl<sub>2</sub>:MeOH, 9:1) to provide the title compound (66% yield). Mass spectrum (m/e): 384 (M<sup>+</sup>+1).

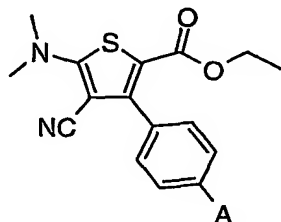
General Example E-14-Cyano-3-(4-A-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester

Add ethylthioglycolate (3.8 mmol) to a stirring suspension of 3,3-bis-methylsulfanyl-2-(4-A-benzoyl)-acrylonitrile, prepared in preparation 29, (3.46 mmol) in 15 ml of EtOH, followed by Et<sub>3</sub>N (3.8 mmol). Heat the mixture to reflux temperature and remove the heat as soon as reflux is reached. Cool the mixture and evaporate a little

amount of solvent under vacuum until a solid precipitates. Filter to collect the solid and wash with cold ethanol to provide the title compound.

#### General Example E-2

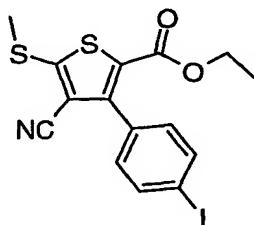
5      4-Cyano-5-dimethylamino-3-(4-A-phenyl)-thiophene-2-carboxylic acid ethyl ester



10      Add ethylthioglycolate (3.8 mmol) to a stirring suspension of 2-(4-A-benzoyl)-3-dimethylamino-3-methylsulfanyl-acrylonitrile, prepared in preparation 33, (3.46 mmol) in 15 ml of EtOH. Add Et<sub>3</sub>N (3.8 mmol) and heat the mixture to reflux temperature and turn off the heat as soon as reaching reflux. Cool the mixture and evaporate a little amount of solvent under vacuum until a solid precipitates. Filter the solid and wash with cold ethanol to provide the title compound.

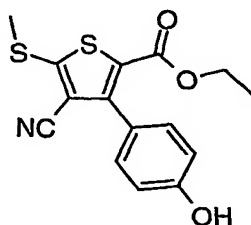
#### Example E-3

15      3-(4-Iodophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester



20      By using a similar procedure as described in general preparation 28, 29 and general example E-1 the title compound is prepared using 4-iodobenzoyl chloride: <sup>1</sup>H NMR (500 MHz, DMSO): δ 7.82(d, 2H), 7.23(d, 2H), 4.12(q, 2H), 2.81(s, 3H), 1.11(t, 3H).



Example E-43-(4-Hydroxyphenyl)-4-Cyano-5-methylsulfanyl -thiophene-2-carboxylic acid ethyl ester

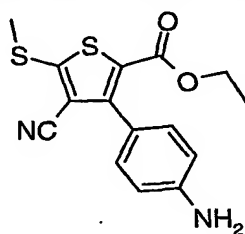
## Step 1

- 5 Follow the procedure set forth in general preparations 28, 29, and general example E-1, using 4-methoxybenzoyl chloride to form 3-(4-methoxyphenyl)-4-cyano-5-methylsulfanyl -thiophene-2-carboxylic acid ethyl ester.

## Step 2

- 10 Add 0.45 mmol of BBr<sub>3</sub> (1.0M solution in CH<sub>2</sub>Cl<sub>2</sub>) to a solution of the previously prepared methoxy analog (0.3 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (7.0 mL) cooled at -78°C. Stir at -20°C for 16h. Add water and extract with ethyl acetate (2x10 mL). Dry over Na<sub>2</sub>SO<sub>4</sub>, filter and evaporate to dryness to provide the title compound which is used without further purification. MS (ES<sup>+</sup>, m/e): 320 (M+1).

15

Example E-53-(4-Aminophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester

## Step 1

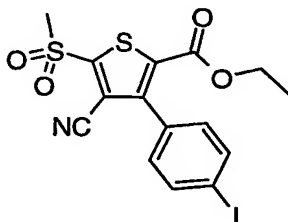
- 20 Follow the procedure set forth in general preparations 28, 29, and general example E-1, using 4-nitrobenzoyl chloride to form 3-(4-nitrophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester.

## Step 2

Add anhydrous  $\text{SnCl}_2$  (7.0 equivalents) to a solution of the previously prepared nitro analog (4.6 mmol) in EtOH (40 mL). Heat the reaction at  $75^\circ\text{C}$  for 30 min and then at room temperature overnight. Add a saturated solution of  $\text{NaHCO}_3$  (pH=11-12) and extract with ethyl acetate (2x50 mL). Dry over  $\text{Na}_2\text{SO}_4$ , filter and evaporate to dryness to provide the title compound which is used without further purification. Yield 70%; MS (ES+, m/e): 319 (M+1).

#### Example E-6

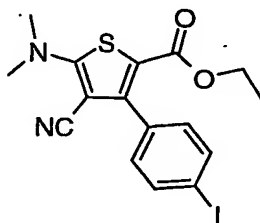
##### 3-(4-Iodophenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester



Add slowly m-chloroperbenzoic acid 70% (MCPBA) (8.4 mmol) to a solution of 3-(4-iodophenyl)-4-cyano-5-methylsulfonyl-thiophene-2-carboxylic acid ethyl ester, prepared in Example E-3, (2.8 mmol) in  $\text{CH}_2\text{Cl}_2$  (5 mL) and cool to  $0^\circ\text{C}$ . Remove the ice-bath and stir the reaction. After 3 days, dilute with 10mL of  $\text{CH}_2\text{Cl}_2$  and wash with 10% aqueous  $\text{NaHSO}_3$  (1x10mL), water (1x10mL), saturated  $\text{NaHCO}_3$  (1x10mL) and brine (1x10mL). Dry over  $\text{Na}_2\text{SO}_4$ , filter and evaporate to dryness to provide the title compound which is used without further purification. Yield 90%. MS (ES+, m/e)= (M<sup>+</sup>+1).

#### Example E-7

##### 3-(4-Iodophenyl)-4-Cyano-5-dimethylamino-thiophene-2-carboxylic acid ethyl ester

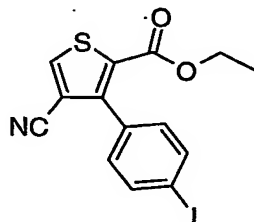


Add 3mL of 2N dimethylamine in THF to 3-(4-iodophenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester (0.23 mmol) and stir under

nitrogen at room temperature for 2h. Evaporate to dryness to provide the title compound which is used without further purification. Yield 95%. MS (ES+, m/e)= 427 (M<sup>+</sup>+1).

#### Example E-8

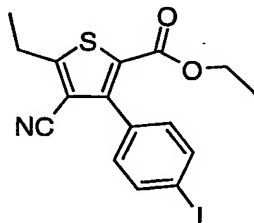
##### 3-(4-Iodophenyl)-4-cyano-thiophene-2-carboxylic acid ethyl ester



Add NaBH<sub>4</sub> (0.26 mmol) to a solution of 3-(4-iodophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester, prepared in example E-3, in 2 mL of EtOH at 0°C. Remove the ice-bath and stir at room temperature. After 30 min, add additional NaBH<sub>4</sub> (0.26 mmol) and stir and additional 30 minutes. Remove the solvent in vacuo and extract the residue with 50 mL of 1/9 MeOH/CH<sub>2</sub>Cl<sub>2</sub>. Evaporate and chromatograph (hexane: ethyl acetate 3:1) over silica gel to provide the title compound: MS (ES+, m/e): 384 (M+1).

#### Example E-9

##### 3-(4-Iodophenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

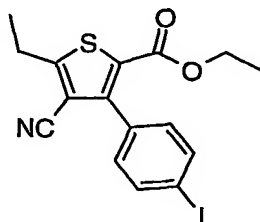


Add dropwise diethylzinc (1.0M in hexanes, 16 mmol) to a solution of 3-(4-iodophenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester (2.78 mmol) in 15 mL of anhydrous CH<sub>2</sub>Cl<sub>2</sub> and stir under nitrogen at room temperature for 5 days. Cool to 0°C and carefully quench with ice followed by 10 mL of saturated NH<sub>4</sub>Cl. Filter the mixture through Celite and rinse the filter pad with 100 mL of CH<sub>2</sub>Cl<sub>2</sub>. Wash the combined organic layers with brine (1x20mL), dry over Na<sub>2</sub>SO<sub>4</sub>, filter, and evaporate.

Chromatograph (hexane: ethyl acetate 3:1) over silica gel to provide the title compound:  
MS (ES+, m/e): 412 (M+1).

#### Example E-10

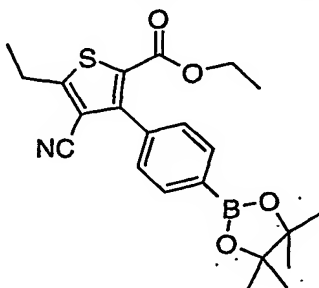
##### 5 4-Cyano-5-ethyl-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester



Add dropwise diethylzinc (1.0M in hexanes, 7 ml, 6.99 mmol, 3 eq) to a mechanically stirring suspension of 4-cyano-3-(4-iodo-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (1 gr, 2.33 mmol) and 1,3-bis-  
10 (diphenylphosphino)propane nickel (II) chloride (24 mg, 0.0466 mmol, 0.02 eq) in dry THF (12 ml) and heat the resulting mixture 60 °C for 30 min. Cool the reaction to room temperature and remove solvents in vacuo. Purify the solid by chromatography on silica gel (eluting with 10-80% ethyl acetate/hexane) to provide the title compound in 60%  
15 yield: Mass spectrum (EI+): m/z 412 (M<sup>+</sup>+1); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 200 MHz): δ 7.72 (d, 2H, J=8.5); 7.05 (d, 2H, J=8.5); 4.14 (q, 2H, J=7.2); 3.01 (q, 2H, J=7.2); 1.36 (t, 3H, J=7.5); 1.17 (t, 3H, J=7.2).

#### Example E-11

##### 20 4-Cyano-5-ethyl-3-[4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-thiophene-2-carboxylic acid ethyl ester

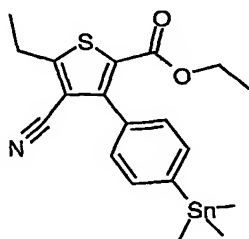


Dissolve 4-cyano-5-ethyl-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester in 3 mL dry CH<sub>3</sub>CN and add Et<sub>3</sub>N (0.15 mL, 1.08 mmol), [1,1'-

bis(disphenylphosphino)-ferrocene]dichloropalladium(II) complex with dichloromethane (25 mg, 0.03 mmol), and pinacolborane (51  $\mu$ L, 0.34 mmol). Heat the mixture to reflux under nitrogen for 5.5 hours. Cool and dilute with 50 mL of EtOAc and wash with water (2 x 20 mL) and brine (1 x 20 mL). Dry over  $\text{Na}_2\text{SO}_4$ , filter through Celite® and evaporate  
5 to 122 mg. Use the crude boronate without further purification.

#### Example E-12

##### 4-Cyano-5-ethyl-3-(4-trimethylstannyl-phenyl)-thiophene-2-carboxylic acid ethyl ester

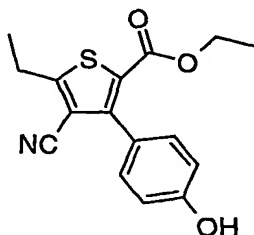


10 Add bis-trimethyltin (0.878 g, 2.67 mmol) and dichlorobis(triphenylphosphine)-palladium(II) (0.085 g, 0.121 mmol) to a solution of 4-cyano-5-ethyl-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester (1.0 g, 2.43 mmol) in dry dimethylformamide (5 mL), heat at 80 °C under nitrogen. After 2 h, add water and extract with ethyl acetate. Combine the organic layers, dry over sodium sulfate, filter and concentrate under reduced  
15 pressure to give a residue. Purify the residue by flash chromatography (silica gel) eluting with ethyl acetate:hexane 1:10 to provide the title compound (0.89 g, 82%):  $^1\text{H-NMR}$  ( $\text{CDCl}_3$ )  $\delta$  0.31 (s, 9 H,  $J^{118}_{\text{Sn}} = 5.3$  Hz,  $J^{119}_{\text{Sn}} = 1.1$  Hz); 1.21 (t, 3 H,  $J = 7.1$  Hz); 1.43 (t, 3 H,  $J = 7.1$  Hz); 3.08 (c, 2 H,  $J = 7.3$  Hz); 4.21 (c, 2 H,  $J = 7.0$  Hz); 7.38-7.70 (m, 4 H).

20

#### Example E-13

##### 4-Cyano-5-ethyl-3-(4-hydroxy-phenyl)-thiophene-2-carboxylic acid ethyl ester



Add 4-cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester (50.0g, 0.149 mol) and 4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenol (Aldrich#52,257-0 or

-114-

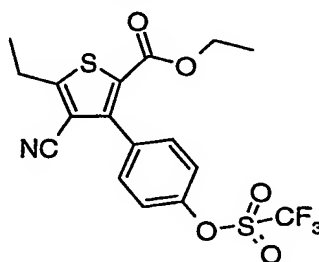
36.1g, 0.164 mol) to a 2000 mL, 3-neck round-bottom flask equipped with magnetic stir bar, internal temperature probe and glycol-cooled condenser fitted with a nitrogen inlet. Add absolute ethanol (250 mL) to the reaction flask. Add a solution of potassium carbonate (61.9g, 0.448 mol) in water (250 mL) to the flask, follow by palladium black (794 mg, 0.00746 mol). Stir and heat the mixture under nitrogen at 70° C for 3 hours.

Filter the reaction mixture through a pre-saturated Celite® with ethyl acetate. Wash the collected solids with ethyl acetate (500 mL). Neutralize the filtrate with 1N HCl (450 mL) and extract the aqueous phase with ethyl acetate (2 x 200 mL). Combine the organic extracts and concentrate the solution under reduced pressure to afford a brown, semi-solid product (59.9g) contaminated with pinacol. Dilute the crude material with water (100 mL) and heat to 70° C for 15 minutes. Decant the dark colored aqueous supernatant, replace with fresh water (100 mL) and reheat to 70° C. Decant the aqueous supernatant and add water (100 mL) to the flask again to afford granular tan-brown solids. Filter the solids to give 60.7g of a wet cake that is now free from pinacol. Dissolve the solids in an 80° C solution of ethanol (200 mL) and water (200 mL), and cool slowly for approximately 12 hours with slow stirring. Cool the resulting suspension to 0° C and filter the precipitate through a sintered glass funnel under vacuum. Air-dry the solids for 2 hours to afford the title compound (38.3g, 85.3%) as a tan powder: <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz): δ 7.30 (d, 2H, J=8.7); 6.85 (d, 2H, J=8.4); 4.23 (q, 2H, J=7.2); 3.08 (q, 2H, J=7.2); 1.43 (t, 3H, J=7.5); 1.24 (t, 3H, J=7.2).

#### Example E-14

##### 4-Cyano-5-ethyl-3-(4-trifluoromethanesulfonyloxy-phenyl)-thiophene-2-carboxylic acid

##### ethyl ester



Add 4-cyano-5-ethyl-3-(4-hydroxy-phenyl)-thiophene-2-carboxylic acid ethyl ester

(30.0g, 0.0996 mol) and dichloromethane (550 mL) to a 1000 mL, 3-neck round-bottom flask equipped with magnetic stir bar, internal temperature probe and nitrogen inlet. Add pyridine (12 mL, 0.15 mol) to the dark brown solution and cool the resulting light brown solution to  $-4^{\circ}\text{C}$ . Attach a pressure-equalizing addition funnel containing

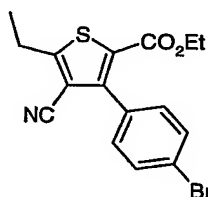
5 trifluoromethanesulfonic anhydride (20 mL, 33.7g, 0.119 mol) and add the funnel contents to the reaction mixture over 6 min. After 60 min, add pyridine (5 mL) and trifluoromethanesulfonic anhydride (10.0 mL) if the reaction is not complete (by HPLC). Add absolute ethanol (250 mL) to the reaction flask. After 135 minutes, pour the reaction mixture into water (1000 mL) and extract with dichloromethane (300 mL). Wash the

10 dichloromethane extract with water (2 x 200 mL) and dry ( $\text{MgSO}_4$ ). Filter the  $\text{MgSO}_4$  and concentrate the filtrate under reduced pressure to afford a light brown powder (40.5g). Triturate the powder with 5:95 ethyl acetate / hexanes (500 mL) at room temperature, filter under vacuum and air-dry to obtain the title compound (37.9g, 87.9%) as a tan powder:  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz):  $\delta$  7.51 (d, 2H,  $J=9.3$ ); 7.37 (d, 2H,  $J=9.0$ ); 4.19 (q,

15 2H,  $J=6.9$ ); 3.10 (q, 2H,  $J=7.5$ ); 1.44 (t, 3H,  $J=7.5$ ); 1.17 (t, 3H,  $J=7.2$ ).

#### Example E-15

##### 3-(4-Bromo-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester



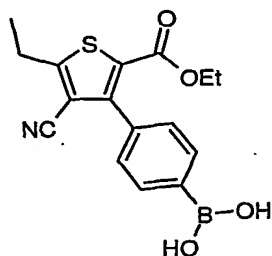
20 Add a solution of 4-cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester (43.0g, 0.128 mol) in dioxane (113 mL) to a suspension of of dichlorobis(tri-o-tolylphosphine)palladium (II) (4.53g, 0.00576 mole) in propionitrile (213 mL) within a 1000 mL, 3-neck round-bottom flask equipped with magnetic stir bar, internal temperature probe, and a glycol-cooled condenser fitted with a nitrogen inlet. Add a

25 turbid solution of 4-bromophenyl boronic acid (28.7g, 0.141 mol), sodium carbonate (14.5g, 0.137 mol) in water (100 mL) and dioxane (100 mL) to the reaction vessel. Add an additional portion of sodium carbonate (14.0g, 0.132 mol) and stir the reactor contents at room temperature while sparging (subsurface) with nitrogen for 5 min. Heat the reaction mixture to  $75^{\circ}\text{C}$  and observe that the reaction mixture gradually darkens to deep

red over 1 hour. Observe that HPLC analysis indicates substantial consumption of 4-bromophenyl boronic acid and 4-cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester (flow rate: 1.5 mL/min; detection: 210 nm; mobile phase: isocratic 65/35 (v/v) acetonitrile / 0.1% trifluoroacetic acid in water; column: Zorbax® SB-Phenyl; 4.6 mm x 25 cm; 5 microns at 35 C). Cool the mixture to 30° C and separate the phases. Extract the aqueous phase with dichloromethane (100 mL). Combine the organic phases and concentrate under reduced pressure to afford an oil (62g). Extract the oil twice with heptane (250 mL and 100 mL) at 85° C and decant the supernatant to leave a dark insoluble oil (6.0g). Combine the heptane extracts and stir with silica gel (5.0g) for 3 minutes. Filter the mixture and concentrate the filtrate under reduced pressure to afford a solid. Triturate the solids with pentane (150 mL) and recover the solids by filtration followed by air-drying to afford the crude title compound (37.5g). Dissolve the crude title compound in a mixture of pentane (600 mL) and cyclohexane (150 mL) at 44° C and stir the resulting solution with silica gel (2.5 g) for 3 min. Filter the mixture and concentrate the filtrate under reduced pressure to a volume of 200 mL. Filter the resulting suspension and wash the filter cake with pentane (3 x 30 mL) and dry in a vacuum oven (40° C) to afford the title compound (28.5g, 61.1%): <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz): δ 7.58 (d, 2H, J=8.4); 7.29 (d, 2H, J=8.7); 4.21 (q, 2H, J=7.2); 3.09 (q, 2H, J=7.5); 1.43 (t, 3H, J=7.5); 1.22 (t, 3H, J=7.2).

#### Example E-16

##### 3-(4-Boronic acid-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester



Stir and heat the mixture of 4-cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester (500 mg, 1.49 mmol), bis-phenylboronic acid (500 mg, 3 mmol, 2 eq), 1,1'-bis(diphenylphosphino)ferrocenedichloropalladium(II) (130 mg, 0.149 mmol, 0.1 eq) in sodium carbonate 2M solution (3 mL, 5.96 mmol, 4 eq) and DME (12.5 mL) at 90°C for 30



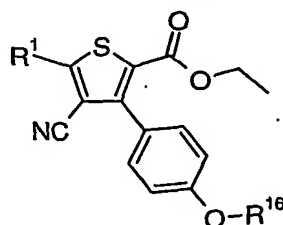
-117-

min. Pour the reaction mixture into water and extract with dichloromethane. Wash the dichloromethane extract with HCl 10% and dry ( $\text{MgSO}_4$ ). Filter the  $\text{MgSO}_4$  and concentrate the filtrate under reduced pressure to afford a light brown powder.

Purification by extraction cartridge (waters Oasis® HLB 20cc, 1 gr LP Extraction cartridges) to provide the title compound in 50% yield: Mass spectrum ( $\text{EI}^+$ ):  $m/z$  330 ( $\text{M}^++1$ );  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 200 MHz):  $\delta$  8.0 (s, 2H); 7.78 (d, 2H,  $J=8.06$ ); 7.4 (d, 2H,  $J=8.06$ ); 4.18 (q, 2H,  $J=7.2$ ); 3.08 (q, 2H,  $J=7.2$ ); 1.43 (t, 3H,  $J=7.5$ ); 1.17 (t, 3H,  $J=7.2$ ) plus biscoupled product 4-Cyano-5-ethyl-3-{4-(4-cyano-5-ethyl) thiophen-3-yl-phenyl}-thiophene-2-carboxylic acid ethyl ester in 7% yield Mass spectrum ( $\text{EI}^+$ ):  $m/z$  493. ( $\text{M}^++1$ ).

### General Example E-17

#### 3-(4-OR<sup>16</sup>-phenyl)-4-cyano-5-R<sup>1</sup>-thiophene-2-carboxylic acid ethyl ester



#### General Example E-17-A

Stir and heat at 85°C a suspension of 4-cyano-3-(4-hydroxy-phenyl)-5-R<sup>1</sup>-thiophene-2-carboxylic acid ethyl ester (0.157 mmol), R<sup>16</sup>-X (0.235 mmol, 1.5 eq) and base (0.47 mmol, 3 eq) in 2 ml of acetonitrile for 24 hours. Check for lack of starting material by t.l.c.(hexane:ethyl acetate, 8:1). Pour the reaction mixture into water and extract with ethyl acetate. Wash the ethyl acetate, extract with NaCl sat, and dry ( $\text{MgSO}_4$ ). Filter the  $\text{MgSO}_4$  and concentrate the filtrate under reduced pressure to afford the title compound.

#### General Example E-17-B

Combine and stir a mixture of 4-cyano-3-(4-hydroxy-phenyl)-5-R<sup>1</sup>-thiophene-2-carboxylic acid ethyl ester (0.31 mmol), R<sup>16</sup>-OH (0.47 mmol, 1.5 eq) and triphenylphosphine (0.47 mmol, 1.5 eq) in toluene (5 ml) at 0°C under nitrogen atmosphere, add DIAD (93  $\mu\text{l}$ , 0.47 mmol, 1.5 eq) dropwise. After this, let reaction slowly

cool to room temperature over 12 hours. Remove solvent in vacuo and purify the title compound by flash chromatography (hexane: ethyl acetate 4:1).

#### General Example E-17-C

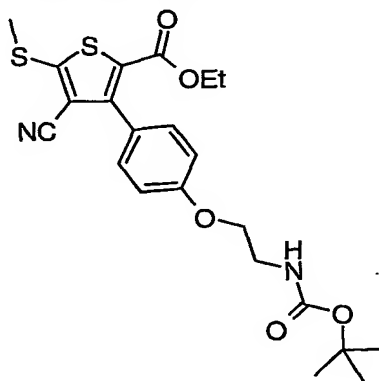
Heat at 90 °C for 12 h a stirring mixture of 4-cyano-3-(4-hydroxy-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (100 mg, 0.31 mmol), 2-fluorobenzonitrile (34  $\mu$ l, 0.31 mmol), 18-crown-6 (9 mg, 0.013 mmol, 0.1 eq), and 40 % w/w KF-Al<sub>2</sub>O<sub>3</sub> (250 mg) in CH<sub>3</sub>CN (2 mL). Cool the reaction mixture to rt, partition between equal amounts of ether and water, and shake vigorously. Draw the aqueous layer and alumina sediments from the funnel, and wash the resulting organic phase once with saturated NaCl (aq), dry (Na<sub>2</sub>SO<sub>4</sub>), filter the Na<sub>2</sub>SO<sub>4</sub>, and concentrate in vacuo. Purification by flash chromatography (hexane: ethyl acetate 4:1) affords the title compound.

#### General Example E-17-D

Stir at room temperature a mixture of 4-cyano-3-(4-hydroxy-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (100 mg, 0.31 mmol), 4-fluorophenylboronic acid (88 mg, 0.63 mmol), copper acetate (56 mg, 0.31 mmol, 1 eq), 4 Å molecular sieves and triethylamine (215  $\mu$ l, 1.55 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (3 mL) for 24 hours. Filter, concentrate in vacuo and purify by flash chromatography (hexane: ethyl acetate 4:1) to give the title compound.

#### Example E-18

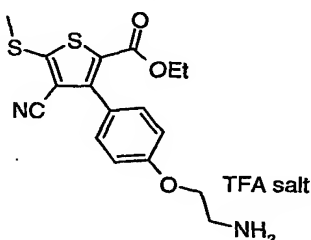
3-[4-(2-tert-Butoxycarbonylamino-ethoxy)-phenyl]-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester



Prepare the title compound in a manner analogous to the procedure set forth in General Example 3-(4-OR<sup>16</sup>-phenyl)-4-cyano-5-R<sup>1</sup>-thiophene-2-carboxylic acid ethyl ester using NHBoc-aminoethanol and eluting with (hexane: ethyl acetate, 4:1). Obtain title compound quantitative. R<sub>f</sub> (hexane: ethyl acetate, 4:1)= 0.2. Mass spectrum (EI+):  
 5 m/z 463 (M<sup>+</sup>+1).

#### Example E-19

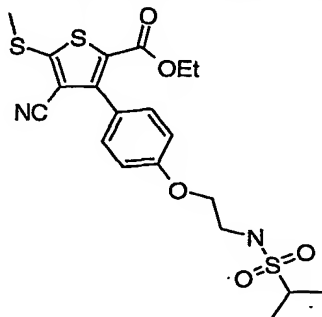
##### 3-[4-(2-Amino-ethoxy)-phenyl]-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester trifluoroacetate salt



Combine 4-cyano-3-{4-[2-(2,2-dimethyl-propionylamino)-ethoxy]-phenyl}-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (211 mg, 0.45 mmol) and CH<sub>2</sub>Cl<sub>2</sub> (1 ml), add trifluoroacetic acid 99% (1 ml) and stir at room temperature for 2 days. Remove the solvents in vacuo to give 222 mg (quantitative yield) of title compound: R<sub>f</sub> (hexane: ethyl acetate, 4:1)= 0.1. Mass spectrum (EI+): m/z 363 (M<sup>+</sup>+1 free base).  
 15

#### Example E-20

##### 4-Cyano-5-methylsulfanyl-3-{4-[2-(propane-2-sulfonylamino)-ethoxy]-phenyl}-thiophene-2-carboxylic acid ethyl ester



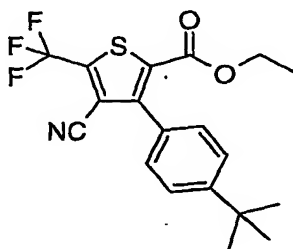
Combine 3-[4-(2-amino-ethoxy)-phenyl]-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (222 mg, 0.46 mmol) and CH<sub>2</sub>Cl<sub>2</sub> (5ml) and stir. Add triethylamine (128μl, 0.92 mmol, 2 eq) and isopropylsulphonyl chloride (103 μl, 0.92  
 20

mmol, 2 eq) at room temperature. Stir the mixture overnight. Remove the solvents in vacuo. Purification by flash chromatography (Hexane:ethyl acetate, 2:1) gives title compound as white solid (59 mg, 30%): R<sub>f</sub> (hexane: ethyl acetate, 1:1)= 0.4; mass spectrum (EI<sup>+</sup>): m/z 469 (M<sup>+</sup>+1).

5

#### Example E-21

##### 3-(4-tert-Butyl-phenyl)-4-cyano-5-trifluoromethyl-thiophene-2-carboxylic acid ethyl ester



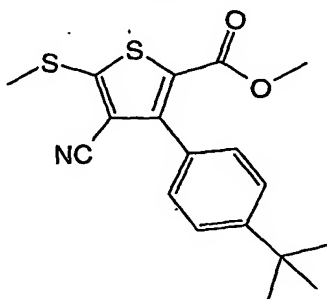
Combine 4-cyano-3-iodo-5-trifluoromethyl-thiophene-2-carboxylic acid ethyl ester (0.136 mmol) with 4-t-butyl-phenyl boronic acid (0.163 mmol), palladium acetate (0.027 mmol), 1,1'-Bis(di-i-propylphosphino)ferrocene (0.027 mmol), and potassium fluoride in DME at room temperature. Stir at room temperature for 17 hours. Concentrate reaction in vacuo and purify by radial chromatography eluting with hexanes / methylene chloride to provide the title compound. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.41 (q, 4H, J=21.7 Hz), 4.26 (q, 2H, J=7.0 Hz), 1.37 (s, 9H) and 1.21 (t, 3H, J=7.3 Hz), <sup>19</sup>F NMR (CDCl<sub>3</sub>) δ -57.2 ppm (s).

15

#### Example E-22

##### 3-(4-tert-Butyl-phenyl)-4-cyano-5-methanesulfanyl-thiophene-2-carboxylic acid methyl ester

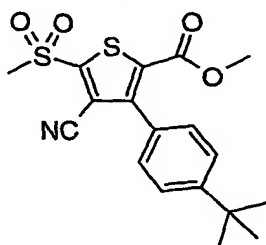
20



By using a method similar to general preparation 28, general preparation 29, general example E-1 obtains the title compound.

Example E-23

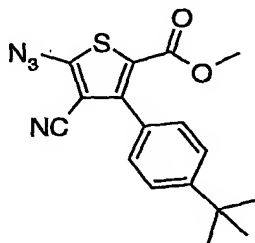
3-(4-tert-Butyl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid methyl ester



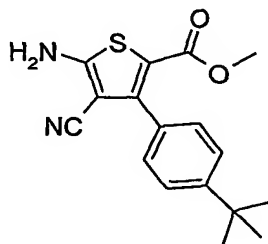
Combine 3-(4-tert-Butyl-phenyl)-4-cyano-5-methanesulfanyl-thiophene-2-carboxylic acid methyl ester (0.29 mmol) and methylene chloride and add m-chloroperoxybenzoic acid (1.02 mmol of 80-85% tech.) and reflux for 30 minutes. Dilute the reaction with methylene chloride and wash with sodium bicarbonate solution. Separate the organic layer and dry over sodium sulfate, filter, and concentrate under reduced pressure to provide the title compound as a white solid.

Example E-24

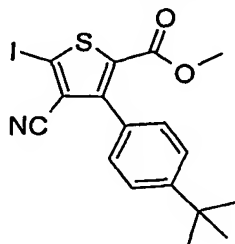
5-Azido-3-(tert-butyl-phenyl)-4-cyano-thiophene-2-carboxylic acid methyl ester



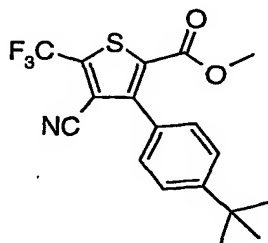
Add sodium azide (1.4 mmol) to a solution of 3-(4-tert-butyl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid methyl ester (0.28 mmol) in DMF and stir the mixture at room temperature for 2.5 hours. Dilute the reaction with diethyl ether and water. Separate the organic layer, dry over sodium sulfate, and concentrate under reduced pressure to provide the title compound as an oil. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.48-7.33 (m, 4H), 3.77 (s, 3H), 1.36 (s, 9H).

Example E-255-Amino-3-(4-tert-butyl-phenyl)-4-cyano-thiophene-2-carboxylic acid methyl ester

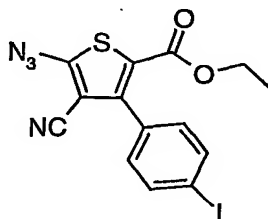
Combine 5-azido-3-(tert-butyl-phenyl)-4-cyano-thiophene-2-carboxylic acid  
5 methyl ester (0.309 mmol) and THF at room temperature and add a fresh THF solution of  
0.1M SmI (0.93 mmol). Stir the reaction for 15 minutes and quench with 2M sodium  
carbonate solution until pH was greater than 9.0. Dilute the reaction with ethyl acetate  
and wash successively with 2M sodium carbonate, water, and brine. Separate the  
organics, dry over sodium sulfate, filter, and concentrate to give the title compound as a  
10 dark solid:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.46-7.36 (m, 4H), 5.23 (s, 2H), 3.71 (s, 3H),  
1.36 (s, 9H), MS found (M+1) 315.1.

Example E-263-(4-tert-butyl-phenyl)-4-cyano-5-iodo-thiophene-2-carboxylic acid methyl ester

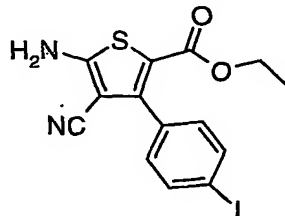
15 Combine 5-amino-3-(4-tert-butyl-phenyl)-4-cyano-thiophene-2-carboxylic acid  
methyl ester (0.29 mmol) in acetonitrile and add diiodomethane (1.02 mmol) and iso-  
amyl nitrite (0.73 mmol) and heat to 100 °C. After 15 minutes, cool the reaction slowly to  
room temperature and stir an additional 1 hour. Concentrate the reaction to a dark oil,  
20 purify by radial chromatography on a 2000 micron silica plate eluting with 50/50  
methylene chloride / hexane and 100% methylene chloride, and concentrate desired  
fractions to give the title compound.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.41 (m, 4H), 3.78 (s,  
3H), 1.37 (s, 9H).

Example E-273-(4-tert-Butyl-phenyl)-4-cyano-5-trifluoromethyl-thiophene-2-carboxylic acid methyl ester

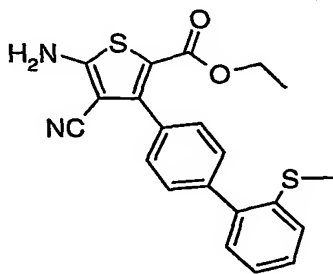
Combine 3-(4-tert-butyl-phenyl)-4-cyano-5-iodo-thiophene-2-carboxylic acid methyl ester (0.08 mmol) and DMF and add methyl 2,2-difluoro-2-(fluoro-sulfonyl)acetate (0.164 mmol), cuprous bromide (0.016 mmol) and heat to 90°C. After 10 minutes, cool the reaction, dilute with diethyl ether, and wash with water and brine. Separate the organics, dry over sodium sulfate, filter, and concentrate in vacuo to a yellow oil. Purify the oil by radial chromatography on a 1000 micron silica plate eluting with methylene chloride / hexane, 3:1. Concentrate the desired fractions to provide the title compound:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.43 (m, 4H), 3.83 (s, 3H), 1.38 (s, 9H),  $^{19}\text{F}$  NMR ( $\text{CDCl}_3$ )  $\delta$  -57.06 ppm (s).

Example E-285-Azido-4-cyano-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester

Using a method substantially in accordance with the method of example 5-azido-3-(tert-butyl-phenyl)-4-cyano-thiophene-2-carboxylic acid methyl ester starting with the compound 3-(4-iodophenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester gives the title compound.

Example E-295-Amino-4-cyano-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester

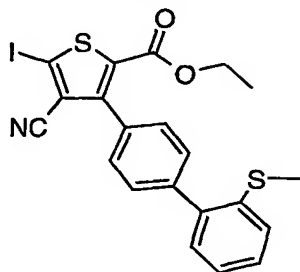
Using a method substantially in accordance with the method of example 5-amino-3-(4-tert-butyl-phenyl)-4-cyano-thiophene-2-carboxylic acid methyl ester starting with the compound 5-azido-4-cyano-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester gives the title compound.

Example E-305-Amino-4-cyano-3-(2'methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

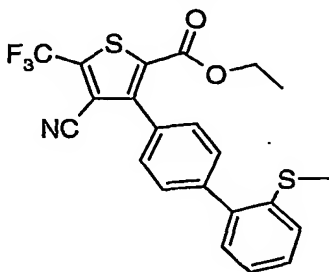
Combine 5-amino-4-cyano-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester (0.829 mmol) in dioxane and add 2-(methylthio)phenylboronic acid, tetrakis(triphenylphosphine)palladium (0), and 1.4 ml of 2M sodium carbonate solution and heat to reflux. After 3 hours, purification by radial chromatography (6000 micron Si plate) eluting with 10-20% ethylacetate / methylene chloride to provide the title compound:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.49-7.19 (m, 8H), 5.26 (s, 2H), 4.17 (q, 2H,  $J=7.2$  Hz), 2.38 (s, 3H), 1.18 (t, 3H,  $J=7.0$  Hz), MS found (M+1) 395.1.



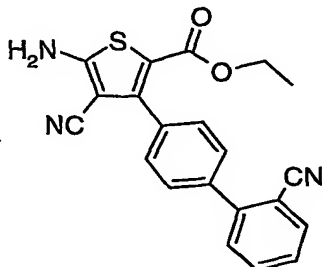
-125-

Example E-314-Cyano-5-iodo-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

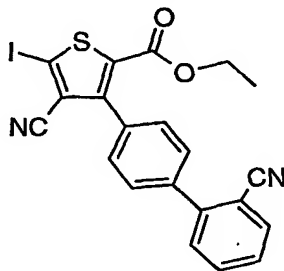
5 Using a method substantially in accordance with the method of 3-(4-tert-butyl-phenyl)-4-cyano-5-iodo-thiophene-2-carboxylic acid methyl ester starting with the compound 5-amino-4-cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester to give the title compound:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.53-7.20 (m, 8H), 4.23 (q, 2H,  $J=7.2$  Hz), 2.38 (s, 3H), 1.22 (t, 3H,  $J=7.0$  Hz).

Example E-334-Cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic acid ethyl ester

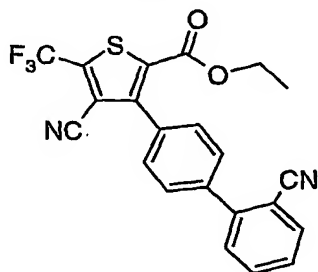
15 Using a method substantially in accordance with the method of 3-(4-tert-butyl-phenyl)-4-cyano-5-trifluoromethyl-thiophene-2-carboxylic acid methyl ester starting with the compound, 4-cyano-5-iodo-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester to give the title compound:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.82-7.47 (m, 8H), 4.27 (q, 2H,  $J=7.2$  Hz), 2.38 (s, 3H), 1.22 (t, 3H,  $J=7.3$  Hz).

Example E-345-Amino-4-cyano-3-(2'-cyano-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

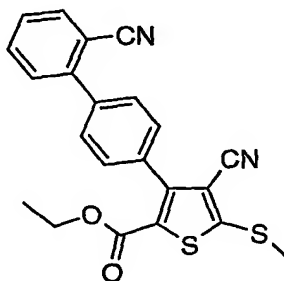
Using a method substantially in accordance with the method of 5-amino-4-cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester starting with the compound 5-amino-4-cyano-3(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester and 2-(cyano)phenylboronic acid to give the title compound:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.81-7.44 (m, 8H), 5.29 (s, 2H), 4.16 (q, 2H,  $J=7.2$  Hz), 1.17 (t, 3H,  $J=7.3$  Hz), MS found (M-1) 372.0 and (M+1)  $+\text{NH}_3$  391.0.

Example E-354-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-iodo-thiophene-2-carboxylic acid ethyl ester

Using a method substantially in accordance with the method of 3-(4-tert-butyl-phenyl-4-cyano-5-iodo-thiophene-2-carboxylic acid methyl ester starting with the compound, 5-amino-4-cyano-3-(2'-cyano-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester to give the title compound:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.81-7.46 (m, 8H), 4.22 (q, 2H,  $J=7.2$  Hz), 1.20 (t, 3H,  $J=7.0$  Hz), MS found (M+1)  $+\text{NH}_3$  502.

Example E-364-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic acid ethylester

- 5        Using a method substantially in accordance with the method of 3-(4-tert-butyl-phenyl)-4-cyano-5-trifluoromethyl-thiophene-2-carboxylic acid methyl ester starting with the compound from example E-35, 4-cyano-3-(2'-cyano-biphenyl-4-yl)-5-iodo-thiophene-2-carboxylic acid ethyl ester, to give the title compound:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.82-7.47 (m, 8H), 4.27 (q, 2H,  $J=7.2$  Hz), 1.22 (t, 3H,  $J=7.3$  Hz),  $^{19}\text{F}$  NMR ( $\text{CDCl}_3$ )  $\delta$  -57.06 ppm (s), MS found (M+1) + $\text{NH}_3$  444.0.
- 10

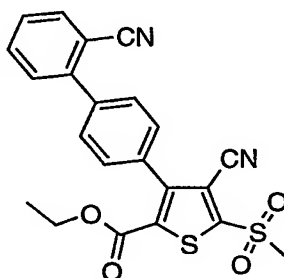
Example E-374-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethylester

- 15        Combine 4-cyano-3-iodo-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (400mg, 1.13 mmol), 2'-carbonitrile-biphenyl-boronic acid (907mg, 4.1mmol), cesium carbonate (2.2g, 6.75 mmol) and tetrakis(triphenylphosphine)-palladium(0) (130mg, 0.11 mmol) in 5mL of tetrahydrofuran/water (4/1) and heat to 80°C under nitrogen with stirring. After 24 hours cool the reaction, dilute with 100mL of ethyl acetate and wash with water (2 x 25mL) and brine (1 x 25mL) and dry over sodium sulfate. Filter the dried solution, evaporate and chromatographe over silica gel, eluting with a gradient of toluene/
- 20

ethyl acetate (100/0 to 98/2), to give the title compound in 20% yield (91mg). HPLC analysis is 96%.

Example E-38

5 4-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester

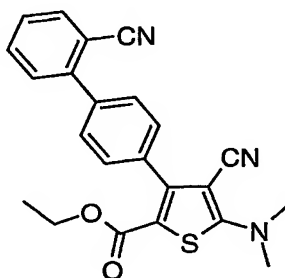


10 Prepare a solution of 4-cyano-3-(2'-cyano-biphenyl-4-yl)-5-methylsulfonyl-thiophene-2-carboxylic acid ethyl ester (200 mg, 0.49 mmol) in 5mL of CH<sub>2</sub>Cl<sub>2</sub>, cool to 0°C and add MCPBA (345 mg, 2.0 mmol). Remove the ice-bath and stir the reaction overnight. Dilute with 50 mL of CH<sub>2</sub>Cl<sub>2</sub> and wash with 10% aqueous NaHSO<sub>3</sub> (1x10 mL), water (1x10 mL), saturated NaHCO<sub>3</sub> (1x10 mL) and brine (1x10 mL). Dry over Na<sub>2</sub>SO<sub>4</sub>, filter and evaporate to a white solid which is used without further purification. Yield = 95 mg (90%). MS (ES+, m/e) = 437 (M<sup>+</sup>+1).

15

Example E-39

4-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-dimethylamino-thiophene-2-carboxylic acid ethyl ester

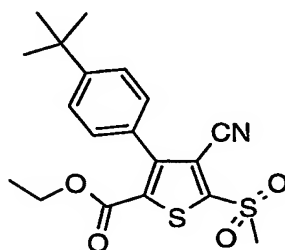


20 Add 4-cyano-3-(2'-cyano-biphenyl-4-yl)-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester (100 mg, 0.23 mmol) to 3 mL of 2N dimethylamine in THF

and stir under nitrogen at room temperature for 90 minutes. Evaporate to a tan solid which is used without further purification. MS(ES<sup>+</sup>, m/e) = 402 (M<sup>+</sup>+1); HPLC = 89%.

Example E-40

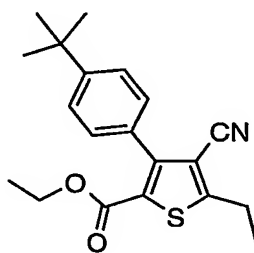
5     3-(4-tert-Butyl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester



10     Prepare the title compound in a manner analogous to the procedure set forth in Example E-38 using 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfonyl-thiophene-2-carboxylic acid ethyl ester.

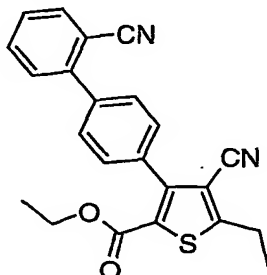
Example E-41

3-(4-tert-Butyl-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

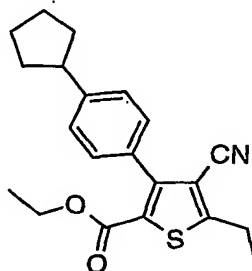


15     Add diethylzinc (1.0M in hexanes, 16 mL, 16 mmol) to a solution of 3-(4-tert-butyl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester (2.78 mmol) in 15 mL of anhydrous CH<sub>2</sub>Cl<sub>2</sub> and stir under nitrogen at room temperature for 5 days. Cool to 0°C and carefully quench with ice followed by 10 mL of saturated NH<sub>4</sub>Cl. Filter the mixture through Celite® and rinse the filter pad with 100 mL of

20     CH<sub>2</sub>Cl<sub>2</sub>. Wash the combined organic layers with brine (1x20 mL), dry over Na<sub>2</sub>SO<sub>4</sub>, filter and evaporate. Chromatograph over silica gel with 100% toluene to give the title compound as a clear oil, 625 mg (66%). MS (FAB) = 341 (M<sup>+</sup>); HPLC = 98%.

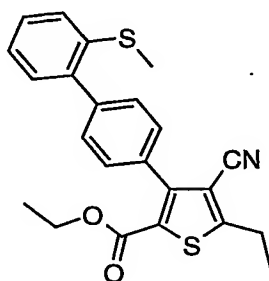
Example E-424-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-ethyl-thiophene-2-carboxylic acid ethyl ester

Prepare a solution of 4-cyano-5-ethyl-3-[4-(4,4,5,5-tetramethyl-  
5 [1,3,2]dioxaborolan-2-yl)-phenyl]-thiophene-2-carboxylic acid ethyl ester (0.26 mmol), 2-iodobenzonitrile (41 mg, 0.18 mmol), 2M aqueous Na<sub>2</sub>CO<sub>3</sub> (0.6 mL, 1.2 mmol) and tetrakis(triphenylphosphine)-palladium(0) (20 mg, 0.02 mmol) in 3 mL of dioxane and heat to 80°C under nitrogen. After 3 hours cool to room temperature, dilute with 50 mL of EtOAc and wash with water (2x10 mL) and brine (1x10 mL). Dry the organics over  
10 Na<sub>2</sub>SO<sub>4</sub>, filter and evaporate. Chromatograph on silica gel (100/0 to 3/1 toluene/EtOAc) to give the title compound as a yellow foam. Yield = 61 mg (91%). HPLC = 80%.

Example E-434-Cyano-3-(4-cyclopentyl-phenyl)-5-ethyl-thiophene-2-carboxylic acid ethyl ester

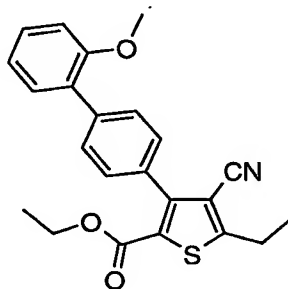
15 Prepare the title compound in a manner analogous to the procedure set forth in Example E-42 using 4-cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester (393 mg, 1.28 mmol) and the crude 2-(4-cyclopentyl-phenyl)-4,4,5,5-tetramethyl-[1,3,2]dioxaborolane by refluxing for 3.5 hours. Yield = 185 mg (41%). HPLC = 91%.

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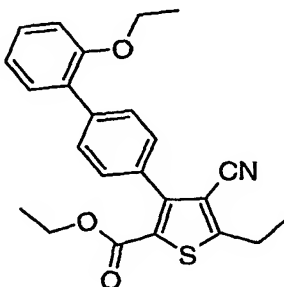
Example E-444-Cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

- 5            Prepare the title compound in a manner analogous to the procedure set forth in Example E-37 using 4-cyano-5-ethyl-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester (315 mg, 0.77 mmol) and 2-thiomethylphenylboronic acid (220 mg, 1.3 mmol). Yield = 244 mg (78%). HPLC = 99%.

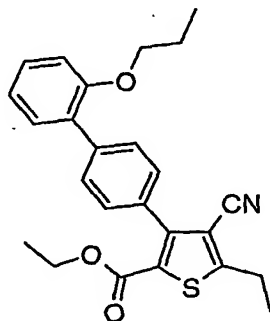
10

Example E-454-Cyano-5-ethyl-3-(2'-methoxy-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

- 15            Prepare the title compound in a manner analogous to the procedure set forth in Example E-37 using 4-cyano-5-ethyl-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester (410 mg, 1.0 mmol) and 2-methoxyphenylboronic acid (280 mg, 1.75 mmol). Yield = 333 mg (85%). HPLC = 99%.

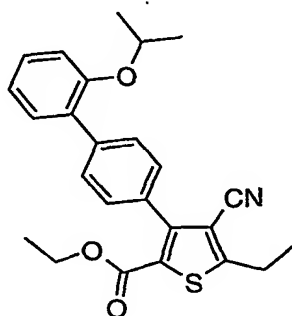
Example E-464-Cyano-3-(2'-ethoxy-biphenyl-4-yl)-5-ethyl-thiophene-2-carboxylic acid ethyl ester

Prepare the title compound in a manner analogous to the procedure set forth in  
5 Example E-37 using 4-cyano-5-ethyl-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester (410 mg, 1.0 mmol) and 2-ethoxyphenylboronic acid (300 mg, 1.81 mmol). Yield = 314 mg (77%). HPLC = 99%.

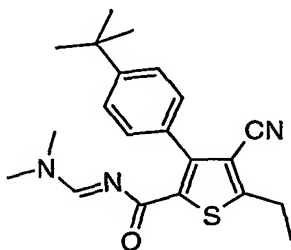
Example E-474-Cyano-5-ethyl-3-(2'-propoxy-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

Add  $K_2CO_3$  (220 mg, 1.6 mmol) to a solution of 4-cyano-5-ethyl-3-(2'-hydroxy-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester (200 mg, 0.53 mmol) in 2 mL of dry DMF at 0°C and stir at this temperature for 1 hour. Treat with n-propyl iodide (0.2  
15 mL, 2 mmol) and allow to warm to room temperature. After 3 hours pour into 25 mL cold 0.2N HCl. Extract with EtOAc (2 x 50 mL) and wash the combined EtOAc layers with water (2x20mL) and brine (1x20mL). Dry over  $Na_2SO_4$ , filter and evaporate to an oil. Chromatograph on silica gel (1/9-1/3 EtOAc/hexanes) to give the title compound as a tan solid, 158 mg (71%). HPLC = 99%.

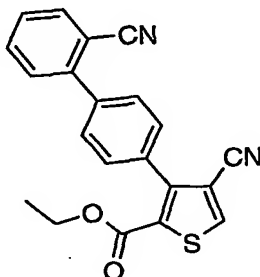


Example E-484-Cyano-5-ethyl-3-(2'-propoxy-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

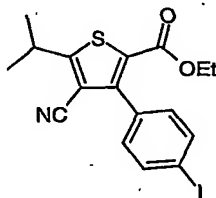
Prepare the title compound in a manner analogous to the procedure set forth in  
5 Example E-47 using 4-cyano-5-ethyl-3-(2'-hydroxy-biphenyl-4-yl)-thiophene-2-  
carboxylic acid ethyl ester (200 mg, 0.53 mmol) and isopropyl iodide. Yield = 169 mg  
(76%). HPLC = 99%.

Example E-493-(4-tert-Butyl-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid  
dimethylaminomethyleneamide

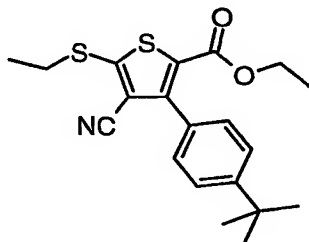
Prepare a solution of 3-(4-tert-butyl-phenyl)-4-cyano-5-ethyl-thiophene-2-  
carboxylic acid amide (270 mg, 0.86 mmol) in 4 mL of dry dimethoxymethyl-dimethyl-  
15 amine and heat to reflux under nitrogen. After 1 hour allow 1 mL of solvent to distill out  
of the reaction, then cool the mixture to room temperature. Dilute the slurry with 10 mL  
of hexanes, filter off the resulting yellow product and wash with 5mL hexanes. Vacuum-  
dry the solid overnight to give 261 mg (82%) of the title compound. MS(ES+, m/e) = 368  
(M<sup>+</sup>+1).

Example E-504-Cyano-3-(2'-cyano-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

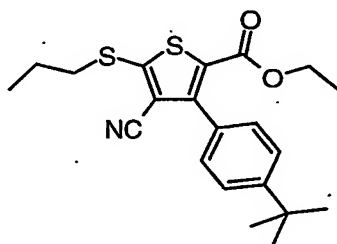
Add NaBH<sub>4</sub> (10 mg, 0.26 mmol) to a solution of 4-cyano-3-(2'-cyano-biphenyl-4-yl)-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester (95 mg, 0.22 mmol) in 2 mL of EtOH at 0°C. Remove the ice-bath and stir at room temperature. After 30 minutes add another 10 mg of NaBH<sub>4</sub> and stir an additional 30 minutes. Remove the solvents in vacuo and extract the residue with 50 mL of 1/9 MeOH/ CH<sub>2</sub>Cl<sub>2</sub>. Evaporate and chromatograph over silica gel (100/0 to 90/10 toluene/EtOAc) to give 44 mg (56%) of the title compound as a white solid. HPLC = 94%.

Example E-514-Cyano-5-isopropyl-3-(4-iodo-phenyl)-thiophene-2-carboxylic acid ethyl ester

Add dropwise isopropylzinc solution (ZnCl<sub>2</sub> 1M in Et<sub>2</sub>O (10.5 ml) and isopropylzinc 2M in THF (10.5 ml) previously mixed at 10°C under N<sub>2</sub> atmosphere) to a mechanically stirring suspension of 4-cyano-3-(4-iodo-phenyl)-5-methylsulfonyl-thiophene-2-carboxylic acid ethyl ester (1.5 g, 3.5 mmol) and 1,3-bis-(diphenylphosphino)propane nickel (II) chloride (380 mg, 0.71 mmol) in dry THF (35 ml) and heat the resulting mixture 60 °C for 1 hour. Cool the reaction to room temperature and remove solvents in vacuo. Purify the solid by chromatography on silica gel (eluting with 10-80% ethyl acetate/hexane) to provide the title compound in 25% yield: Mass spectrum (EI<sup>+</sup>): m/z 426 (M<sup>+</sup>+1).

Example E-523-(4-tert-Butyl-phenyl)-4-cyano-5-ethylsulfanyl-thiophene-2-carboxylic acid ethyl ester

Combine 3-(4-tert-Butyl-phenyl)-4-cyano-5-ethylsulfanyl-thiophene-2-carboxylic  
5 acid ethyl ester (0.14 mmol), ethanethiol (0.28 mmol), sodium tertbutoxide (0.21 mmol)  
and (R)-(+)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthyl (0.015 mmol) and  
tetrakis(triphenylphosphine)-palladium(0) (0.007 mmol) in 2 mL of toluene and heat to  
90°C under nitrogen with stirring overnight. Filter the reaction mixture over celite and  
evaporate the solvents under vacuum. Chromatograph on silica gel, eluting with a  
10 gradient of 1/3 ethyl acetate/hexane to give the title compound as a yellow solid  
(quantitative yield). Mass spectrum (m/e): 374 (M+1).

Example E-533-(4-tert-Butyl-phenyl)-4-cyano-5-propylsulfanyl-thiophene-2-carboxylic acid ethyl ester

15

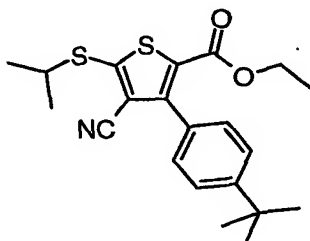
Prepare the title compound in a manner analogous to the procedure set forth in  
example E-52, 3-(4-tert-Butyl-phenyl)-4-cyano-5-ethylsulfanyl-thiophene-2-carboxylic  
acid ethyl ester to provide the title compound. Mass spectrum (m/e): 388 (M+1).

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Example E-54

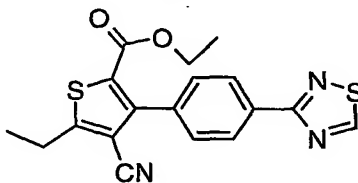
3-(4-tert-Butyl-phenyl)-4-cyano-5-isopropylsulfanyl-thiophene-2-carboxylic acid ethyl ester



5 Prepare the title compound in a manner analogous to the procedure set forth in example E-52, 3-(4-tert-Butyl-phenyl)-4-cyano-5-ethylsulfanyl-thiophene-2-carboxylic acid ethyl ester to provide the title compound. Mass spectrum (m/e): 388 (M+1).

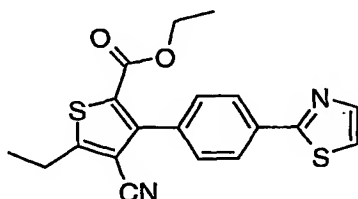
Example E-55

10 4-Cyano-5-ethyl-3-(4-[1,2,4]-thiadiazol-2-yl-phenyl)-thiophene-2-carboxylic acid ethyl ester

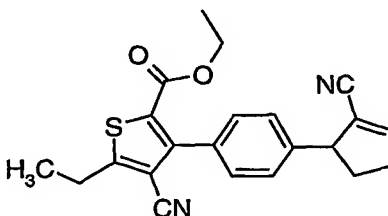


Add DME (3 mL) to a mixture of 3-[4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-[1,2,4]thiadiazole (0.066 g, 0.23 mmol), 4-Cyano-3-iodo-5-ethyl-thiophene-2-carboxylic acid ethyl ester (0.071 g, 0.20 mmol), 1,1'-bis(diphenylphosphino)ferrocene palladium(II) dichloride (1:1) dichloromethane complex (0.009 g, 0.01 mmol) and cesium fluoride (0.103 g, 0.68 mmol) under nitrogen and stir at 80°C for 3 h. Cool down and add ice-water and ethyl acetate. Separate layers and wash the organic layer with water (3x) and back-extract the combined aqueous layers with ethyl acetate (2x). Wash the combined organic layers with brine, dry over anhydrous sodium sulfate and concentrate under reduced pressure over Celite®. Purify by flash chromatography (silica gel) eluting with hexanes-ethyl acetate 10:1 first, then 5:1 to give 0.06 g of the title compound as a white solid. Mass spectrum ESI positive (m/z): 370 (M+1).

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Example E-564-Cyano-5-ethyl-3-(4-thiazol-2-yl-phenyl)-thiophene-2-carboxylic acid ethyl ester

Add a solution of 2-(tributylstannyl)thiazole (0.565 g, 1.51 mmol) in dry toluene  
5 (2 mL) to a mixture of 4-cyano-5-ethyl-3-(4-bromo-phenyl)-thiophene-2-carboxylic acid  
ethyl ester (0.5 g, 1.37 mmol) and tetrakis(triphenyl-phosphine)palladium(0) (0.158 g,  
0.14 mmol) in dry toluene (3 mL) under nitrogen atmosphere and stir at 110°C for 3h.  
Concentrate under reduced pressure over Celite® and purify by flash chromatography  
(silica gel) eluting with hexanes-ethyl acetate 9:1, then with 5:1. Wash the product thus  
10 obtained with diethyl ether-hexanes 1:2 to give 0.303 g of pure title product. Mass  
spectrum ESI positive (m/z): 369 (M+1).

Example E-57(R,S) 4-Cyano-3-[4-(2-cyano-cyclopent-2-enyl)-phenyl]-5-ethyl-thiophene-2-carboxylic  
15 acid ethyl ester

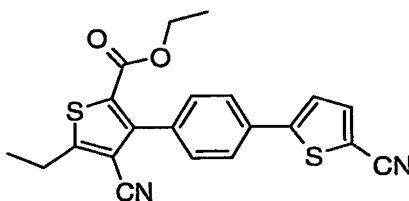
Add dry DMF (4 mL) to a mixture of 4-cyano-5-ethyl-3-(4-  
trifluoromethanesulfonyloxy-phenyl)-thiophene-2-carboxylic acid ethyl ester (1.0 g, 2.3  
mmol), dichloro (bistriphenyl phosphine)palladium(II) (0.160 g, 0.22 mmol), 1,3-  
20 bis(diphenylphosphino)propane (0.105 g, 0.25 mmol), lithium bromide (0.380 g, 4.38  
mmol) and solid sodium bicarbonate (0.385 g, 4.58 mmol) under nitrogen followed by  
addition of 1-cyanocyclopentene (0.4 mL). Heat the mixture to 150°C and stir overnight.  
Cool down, add ethyl acetate and 1.2 M HCl and separate phases. Wash organic layer  
with more 1.2 M HCl (3x) and back-extract the combined aqueous layers with ethyl  
25 acetate once. Wash organic layer with brine, dry over sodium sulfate and concentrate in

vacuo over Celite®. Purify by flash chromatography (silica gel) eluting with hexanes-ethyl acetate 4:1; hexanes-ethyl acetate 1:1, and 100 % ethyl acetate to give 0.160 g of the title compound as a mixture of isomers contaminated with the decarboxylated product: Mass spectrum ESI positive (m/z) 377 (M+1), 394 (M+18).

5

#### Example E-58

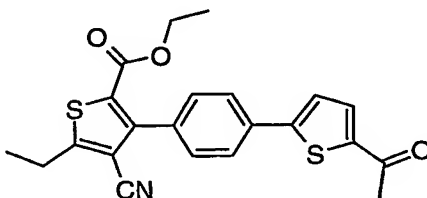
4-Cyano-3-[4-(5-cyano-thiophen-2-yl-phenyl)-5-ethyl thiophene-2-carboxylic acid ethyl ester



10 Mix 4-cyano-5-ethyl-3-(4-bromo-phenyl)-thiophene-2-carboxylic acid ethyl ester(1Equiv.), 5-cyano-2-thiophene boronic acid (1.8 equiv) and tetrakis(triphenylphosphine) palladium(0) (0.09 equiv). Add DME (3 mL), ethanol (1.5 mL), 2M aqueous solution of sodium carbonate (0.55 mL) and stir at 90°C under nitrogen for 24h. Concentrate in vacuo and purify by preparative TLC (2mm of silica gel plates) eluting with hexanes-ethyl acetate gradient (4:1) to give 0.052 g of the title compound as a white solid. Mass spectrum ESI positive (m/z): 393 (M+1), 410 (M+18).

#### Example E-59

3-[4-5-Acetyl-thiophen-2-yl]-phenyl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid, ethyl ester



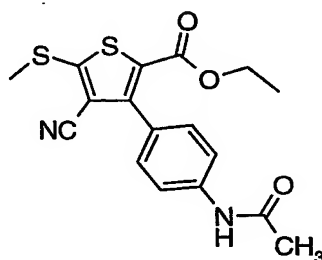
20

Prepare the title compound in a manner analogous to the procedure set forth in Example E-58 using 5-acetyl-2-thiophene boronic acid and stirring for 24h. Concentrate and purify by preparative TLC (2mm of silica gel plates) eluting with hexanes-ethyl

acetate (3:1; 2:1) to give 0.042 g of the title compound as a white solid. Mass spectrum ESI positive (m/z): 410 (M+1).

#### Example E-61

5     3-(4-Acetylaminophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester

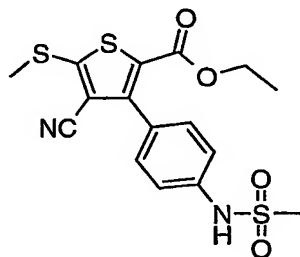


Combine 3-(4-aminophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (0.1 g, 1.0 eq) in  $\text{CH}_2\text{Cl}_2$  (5 mL) and stir. Add triethylamine (1.5 eq) and acetyl chloride (1.0 eq) at room temperature. Stir the mixture overnight. Add a saturated solution of  $\text{NH}_4\text{Cl}$  and extract with  $\text{CH}_2\text{Cl}_2$  (2x50 mL). Dry over  $\text{NaSO}_4$ , filter and evaporate to dryness. Purification by chromatography (hexane: ethyl acetate 4:1) to provide the title compound (0.125 g, yield 90%): MS ( $\text{ES}^+$ , m/e): 361 (M+1).

15

#### Example E-62

4-Cyano-3-(4-methanesulfonylamino-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester

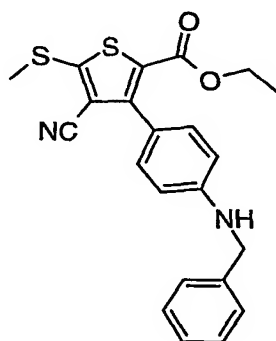


Combine 3-(4-aminophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (0.1 g, 1.0 eq) in  $\text{CH}_2\text{Cl}_2$  (5 mL) and stir. Add triethylamine (1.5 eq) and methanesulfonyl chloride (1.0 eq) at room temperature. Stir the mixture overnight. Add a saturated solution of  $\text{NH}_4\text{Cl}$  and extract with  $\text{CH}_2\text{Cl}_2$  (2x50 mL). Dry over  $\text{NaSO}_4$ , filter

and evaporate to dryness. Purification by chromatography (hexane: ethyl acetate 4:1) to provide the title compound (0.028 g, Yield 25%): MS (ES<sup>+</sup>, m/e): 397 (M+1).

Example E-63

5     3-(4-Benzylamino-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester



Step 1

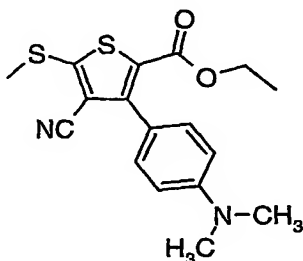
10     Combine 3-(4-aminophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (0.1 g, 1.0 eq) in MeOH (5 mL) and stir under nitrogen atmosphere. Add molecular sieves 4A (0.04 g) and benzaldehyde (2.0 eq) at room temperature. Stir the mixture overnight. Filter through celite and evaporate to dryness.

Step 2

15     Combine the above crude in a mixture of MeOH (3.0 mL) and acetic acid (6.0 mL) and stir at room temperature. Add NaCNBH<sub>3</sub> (1.1 eq). Stir the mixture overnight. Add a saturated solution of NaHCO<sub>3</sub> and extract with CH<sub>2</sub>Cl<sub>2</sub> (2x50 mL). Dry over NaSO<sub>4</sub>, filter and evaporate to dryness. Purification by chromatography (hexane: ethyl acetate 4:1) to provide the title compound (0.030 g, Yield 25%): MS (ES<sup>+</sup>, m/e): 409 (M+1).

20

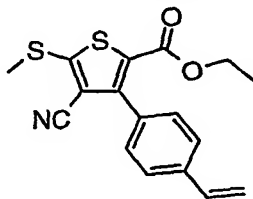


Example E-644-Cyano-3-(4-methylamino-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester

5

Combine 3-(4-aminophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (0.1 g, 1.0 eq) in CH<sub>3</sub>CN (8.0 mL) and stir. Add potassium carbonate (4.0 eq) and methyl iodide dropwise (1.5 eq) at 0°C. Stir the mixture for 3 days at room temperature. Add water and extract with ethyl acetate (2x50 mL). Dry over NaSO<sub>4</sub>, filter and evaporate to dryness. Purification by chromatography (hexane: ethyl acetate 2:1) to provide the title compound (0.007 g, Yield 7%). MS (ES<sup>+</sup>, m/e): 333 (M+1).

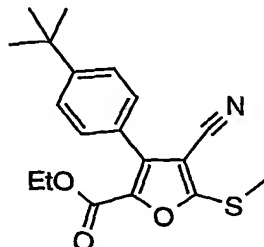
10

Example E-654-Cyano-5-methylsulfanyl-3-(4-vinyl-phenyl)-thiophene-2-carboxylic acid ethyl ester

15

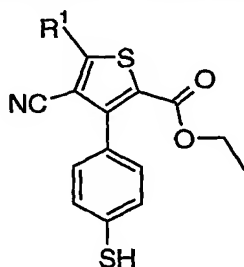
Combine 4-cyano-3-(4-iodo-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (0.1 g, 1.0 eq) in THF (5.0 mL) and stir. Add Pd(PPh<sub>3</sub>)<sub>4</sub> (1%), tributylvinyl-stannane (0.9 eq) and LiCl. Reflux the mixture overnight. Concentrate to dryness, wash with hexane to remove excess of stannane, add water and filter the precipitate to provide the title compound (0.04 g, Yield 38%). MS (ES<sup>+</sup>, m/e): 330 (M+1).

20

Example E-663-(4-tert-Butyl-phenyl)4-cyano-5-methylsulfanyl-furan-2-carboxylic acid ethyl ester

5 Add a solution of the bromoethyl acetate (2.13 ml, 19.17 mmol) in THF (10 ml)  
 dropwise to a  $-78^{\circ}\text{C}$  solution of the lithium hexamethylsilylamide (1M, 21 ml, 20.7  
 mmol) in THF. Stir the mixture at  $-78^{\circ}\text{C}$  for 10 minutes and treat with a dropwise  
 solution of 2-(4-tert-butyl-benzoyl)-3,3-bis-methylsulfanyl-acrylonitrile (2.25 g, 7.67  
 mmol) in THF (20 ml). Stir the mixture at  $-78^{\circ}\text{C}$  for 30 minutes and at RT for 6h. Pour  
 10 into a saturated solution of ammonium chloride (100 ml). Extract organic with EtOAc  
 (3x100 ml). Combine the organics wash with water (3x100 ml), brine (100 ml), dry over  
 magnesium sulfate, filter and concentrate under reduced pressure. Purification by flash  
 chromatography, eluting with ethyl acetate:hexanes (1: 9) to provide the title compound  
 (1g, 38%): Mass spectrum (M+1) = 344.

15

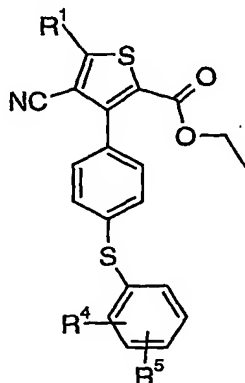
General Example E-674-Cyano-5-R<sup>1</sup>-3-(4-mercaptophenyl)-thiophene-2-carboxylic acid ethyl ester

Place NaH (95% dispersed in oil, 0.222 g, 8.9 mmol) in a dry, 2-necked flask  
 under nitrogen. Add dry THF (20 mL) under nitrogen and cool down the mixture to  $0^{\circ}\text{C}$ .  
 20 Add triisopropyl-silanethiol (1.91 mL, 8.9 mmol) dropwise and stir at  $0^{\circ}\text{C}$  for 15 min and  
 then 5 min at  $23^{\circ}\text{C}$ . Add the reaction mixture to a warm solution of 4-cyano-5-R<sup>1</sup>-3-(4-  
 bromo-phenyl)-thiophene-2-carboxylic acid ethyl ester (2.5 g, 6.85 mmol) and tetrakis  
 (triphenylphosphine)palladium(0) (0.79 g, 0.68 mmol) in dry toluene (30 mL) under  
 nitrogen and stir the resulting mixture under reflux for 3 h and at  $23^{\circ}\text{C}$  overnight. Cool

down the mixture to 0°C and add tetra n-butyl ammonium fluoride (1M solution in THF, 7 mL) and stir 45 min at 0-5°C. Then add glacial acetic acid (5 mL) and continue stirring 5-10 min. Add ethyl acetate and brine. Separate phases and wash organic phase with more brine. Back-extract combined aqueous layers with ethyl acetate. Dry combined organic layers (sodium sulfate) and concentrate in vacuo over Celite®. Purify by flash chromatography (silica gel) eluting with hexanes-ethyl acetate 10:1 to give 1.19 g of the title compound as a white solid: Mass spectrum ESI negative (m/z): 316 (M-1).

#### General Example E-68

#### 4-Cyano-5-R<sup>1</sup>-3-(4-mercapto-R<sup>4</sup>, R<sup>5</sup>-phenyl)-thiophene-2-carboxylic acid ethyl ester



Add a solution of 4-Cyano-5-R<sup>1</sup>-3-(4-mercaptophenyl)-thiophene-2-carboxylic acid ethyl ester (0.106 g, 0.33 mmol) in DMF (0.5 mL) to a suspension of the appropriate aryl halide (0.37 mmol) and potassium carbonate (0.67 mmol) in DMF (1.5 mL) under argon and warm to 100°C in a sealed tube for 1.5 h. Cool down and add diethyl ether. Wash with 1M HCl (x3) and back-extract aqueous phase with diethyl ether. Wash combined organic layers with brine, dry (sodium sulfate-magnesium sulfate) and concentrate in vacuo over Celite®. Purify using SPE Strata® cartridges (silica gel) eluting with a gradient of hexanes-ethyl acetate (15:1 to 1:1).

By using method similar to the method described in general example E-68, the following compounds are prepared:

-144-

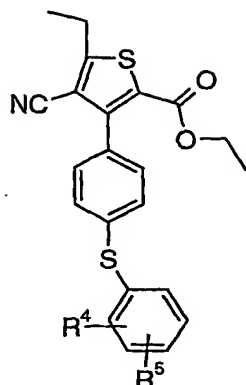
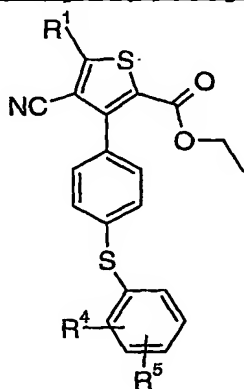


Table E-1:

R<sup>5</sup> is hydrogen

No.	R <sup>4</sup>	Data
E-68A	2-cyano	Mass spectrum (m/z): 419(M+1), 441(M+23)
E-68B	4-cyano	Mass spectrum (m/z): 419(M+1), 441(M+23)
E-68C	2-cyano-5-fluoro	Mass spectrum (m/z): 454 (M+18), 459 (M+23)
E-68D	2-cyano-4-fluoro	Mass spectrum (m/z): 454 (M+18), 459 (M+23)

5

General Example E-694-Cyano-5-R<sup>1</sup>-3-(4-mercapto-R<sup>4</sup>, R<sup>5</sup>-phenyl)-thiophene-2-carboxylic acid ethyl ester

10

Using a Trident® Automated Synthesizer (Argonaut), add the appropriate thiol (R<sup>4</sup>, R<sup>5</sup>-phenylthioether) (1.02 mmol) in dioxane (1 mL) to a mixture of 3-(4-(Bromophenyl)-4-cyano-5-R<sup>1</sup>-thiophene-2-carboxylic acid ethyl ester (0.25 g, 0.68 mmol), tetrakis(triphenylphosphine)palladium(0) (0.158 g, 0.14 mmol) and cesium carbonate (0.031 g, 0.95 mmol) in dioxane (5 mL) under nitrogen in a Trident® reaction vessels using the Trident® work station. Warm the reaction to 110°C and shake 16 h in a

Trident® Automated Synthesizer. Collect automatically using ethyl acetate. Concentrate in vacuo over Celite® and purify using Triconex® flash tubes eluting with hexanes-ethyl acetate.

- 5 By using method similar to the method described in general example E-69, the following compounds in Table E-2 are prepared:

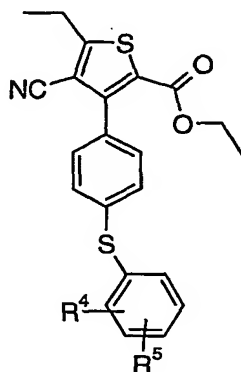


Table E-2:

R<sup>5</sup> is hydrogen

No.	R <sup>4</sup>	Data
E-70	2-methoxy	Mass spectrum (m/z): 424(M+1), 446(M+23)
E-71	H	Mass spectrum (m/z): 394(M+1), 416(M+23)
E-72	2-chloro	Does not ionize *
E-73	3-chloro	Does not ionize *
E-74	4-chloro	Does not ionize *
E-75	3-methoxy	Mass spectrum (m/z): 424(M+1), 446(M+23)
E-78	4-methoxy	Mass spectrum (m/z): 424(M+1), 446(M+23)

\* Structure confirmed by subsequent transformation to the acid

By using method similar to the method described in general example E-68 or general example E-69, the following compounds in Table E-3 are prepared:

-146-

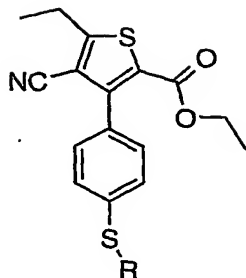


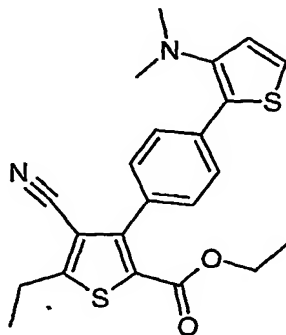
Table E-3

No.	R	Method	Data
E-79	<i>n</i> -propyl	E-69	Mass spectrum (m/z): 360(M+1), 382(M+23)
E-80	cyclopentyl	E-69	Mass spectrum (m/z): 386(M+1), 408(M+23)
E-80A	2-(4-pyridyl)ethyl	E-69	
E-80B	2-(2-pyridyl)ethyl	E-69	Mass spectrum (m/z): 423(M+1), 445(M+23)
E-80C	4-pyridyl	E-68	Mass spectrum (m/z): 395 (M+1)

5

Example E-81

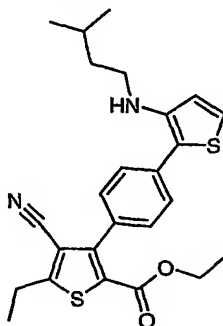
4-Cyano-3-[4-(3-dimethylamino-thiophen-2-yl)-phenyl]-5-ethyl-thiophene-2-carboxylic acid ethyl ester



Prepare with procedure described in literature Sznajdman M. L.; Meade E. A.;  
Beauchamp, L. M.; Russell, R.; Tisdale, M., *Bioorg. Med. Chem. Lett.*, **1996**, 6, 5, 565-  
568. Stir at room temperature under nitrogen a mixture of 3-[4-(3-amino-thiophen-2-yl)-  
phenyl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (0.05 g, 0.131 mmol),  
5 paraformaldehyde (0.041 g, 1.31 mmol), sodium cyanoborohydride (0.026 g, 0.393  
mmol) and acetic acid (0.02 mL, 0.262 mmol) in dry acetonitrile (1 mL). After 3 h add  
water and extract with ethyl acetate. Combine the organic layers, dry over sodium sulfate,  
filter and concentrate under reduced pressure to give a residue. Purify the residue by flash  
chromatography (silica gel) eluting with ethyl acetate:hexane 1:2 to provide the title  
10 compound (0.033 g, 61%). Mass spectrum (m/e): 411 (M+1). <sup>1</sup>H-NMR (CDCl<sub>3</sub>) δ 1.19 (t,  
3 H, J = 7.2 Hz); 1.44 (t, 3 H, J = 7.5 Hz); 2.71 (s, 6 H); 3.09 (c, 2 H, J = 7.5 Hz); 4.20 (c,  
2 H, J = 7.2 Hz); 6.97 (d, 1 H, J = 5.4 Hz); 7.19 (d, 1 H, J = 5.6 Hz); 7.38-7.43 (m, 2 H);  
7.81-7.86 (m, 2 H).

15 Example E-82

4-Cyano-5-ethyl-{4-[3-(3-methyl-butylamino)-thiophen-2-yl]-2-carboxylic acid ethyl  
ester



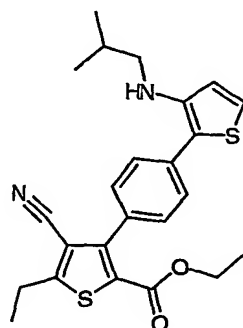
Add sodium triacetoxy borohydride (0.039 g, 0.183 mmol) to a mixture of 3-[4-(3-  
20 amino-thiophen-2-yl)-phenyl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester  
(0.050 g, 0.131 mmol), 3-methyl butanal (0.016 mL, 0.144 mmol) and acetic acid (0.08  
mL, 0.131 mmol) in dichloroethane (2 mL) and stir the mixture at room temperature under  
nitrogen for 3 h. Add a saturated solution of NaHCO<sub>3</sub> (10 mL) and extract with CH<sub>2</sub>Cl<sub>2</sub>.  
Combine the organic layers, dry over Na<sub>2</sub>SO<sub>4</sub>, filter and concentrate under reduced  
25 pressure to give a residue. Purify the residue by flash chromatography (silica gel) eluting  
with EtOAc/Hexane 1:7 to provide the title compound (0.026 g, 44%). Mass spectrum

(m/e): 453 (M+1).  $^1\text{H-NMR}$  ( $\text{CDCl}_3$ )  $\delta$  0.93 (d, 6 H,  $J = 5.5$  Hz); 1.22 (t, 3 H,  $J = 6.9$  Hz); 1.42-1.53 (m, 5 H); 1.62-1.73 (m, 1 H); 3.06-3.21 (m, 4 H); 4.22 (c, 2 H,  $J = 7.3$  Hz); 6.80 (d, 1 H,  $J = 5.6$  Hz); 7.20 (d, 1 H,  $J = 5.6$  Hz); 7.26-7.44 (m, 2 H); 7.47-7.59 (m, 2 H).

5

Example E-83

4-Cyano-5-ethyl-{4-[3-(3-methyl-butylamino)-thiophen-2-yl]-2-carboxylic acid ethyl  
ester



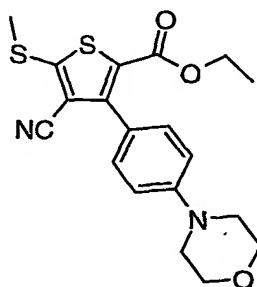
Prepare the title compound in a manner analogous to the procedure set forth in  
example E-82 using isobutyraldehyde. Purify the residue by flash chromatography (silica  
gel) eluting with EtOAc/Hexane 1:7 to provide the title compound. Mass spectrum (m/e):  
439 (M+1).  $^1\text{H-NMR}$  ( $\text{CDCl}_3$ )  $\delta$  0.95 (d, 6 H,  $J = 6.5$  Hz); 1.22 (t, 3 H,  $J = 6.7$  Hz); 1.44  
(t, 3 H,  $J = 7.6$  Hz); 1.85 (sp, 1 H,  $J = 6.8$  Hz); 2.99 (d, 2 H,  $J = 6.5$  Hz); 3.10 (c, 2 H,  $J =$   
7.7 Hz); 4.22 (c, 2 H,  $J = 6.9$  Hz); 6.77 (d, 1 H,  $J = 5.6$  Hz); 7.20 (d, 1 H,  $J = 5.2$  Hz);  
7.45-7.48 (m, 2 H); 7.57-7.61 (m, 2 H).

15

Example E-84

4-Cyano-5-methylsulfanyl-3-(4-morpholin-4-yl-phenyl)-thiophene-2-carboxylic acid ethyl  
ester

20

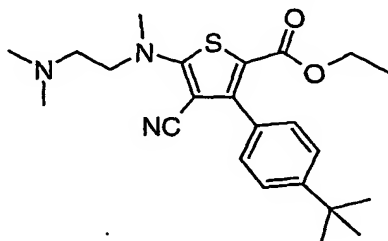




Combine 3-(4-iodophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (50 mg, 0.12 mmol), morpholine (20  $\mu$ l, 0.23 mmol),  $\text{Pd}_2(\text{dba})_3$  (3.5 mg, 0.006 mmol), cesium carbonate (53 mg, 0.16 mmol) and (+)-BINAP (5.4 mg, 0.009 mmol) in anhydrous toluene (1 ml) and stir at 100°C for 12 hours. Cool the reaction mixture to room temperature, filtered through celite and washed with ethyl acetate. Evaporate the solvent and purify the residue by column chromatography (silica gel) eluting with ethyl acetate:hexane 1:3 to provide the title compound (22mg, 49%):  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 200 MHz):  $\delta$  7.37 (d, 2H, J=8.9); 6.99 (d, 2H, J=8.9); 4.22 (q, 2H, J=7.2); 3.89 (m, 4H); 3.28 (m, 4H); 2.71 (s, 3H); 1.24 (t, 3H, J=7.2).

#### Example E-85

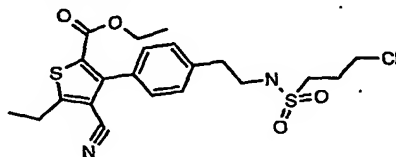
3-(4-tert-Butyl-phenyl)-4-cyano-5-[(2-dimethylamino-ethyl)-methyl-amino]-thiophene-2-carboxylic acid ethyl ester



Add N,N,N'-Trimethyl-ethane-1,2-diamine (1.21 mmol) to a solution of 3-(4-tert-butyl-phenyl)-4-cyano-5-methanesulfanyl-thiophene-2-carboxylic acid ethyl ester (Example A-4) (0.061 mmol) in DMF (1 ml) and stir the mixture at room temperature for 16 hours. Dilute the reaction with ethyl acetate and wash with ice-water. Separate the organic layer, dry over magnesium sulfate, and concentrate under reduced pressure to provide the title compound (90% yield). (EI+):  $m/z$  414 ( $\text{M}^++1$ ).

#### Example E-86

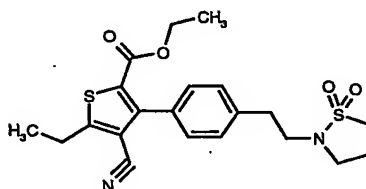
3-{4-[2-(3-Chloropropane-1-sulfonylamino)-ethyl]phenyl}-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester



Prepare the title compound in a manner analogous to the procedure set forth in preparation of Example E-55 using boronate, 3-chloropropane-1-sulfonic acid {2-[4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-ethyl}-amide, and stirring 2 h at 90°C. Purify by flash chromatography (silica gel) eluting with hexanes-ethyl acetate 2:1 to obtain 0.078 g of the title compound as pale yellow solid. Mass spectrum ESI positive (m/z): 469 (M+1), 486 (M+18), 461 (M+23).

#### Example E-87

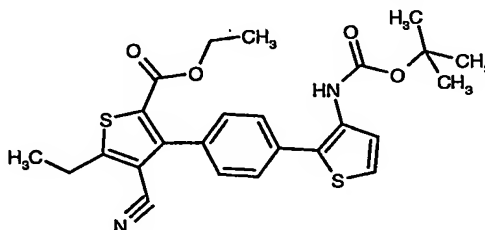
4-Cyano-3-{4-[2-(1,1-dioxo-1 $\lambda$ 6-isothiaolidin-2-yl)-ethyl]phenyl}-5-ethyl-3-(4-[1,2,4]-thiadiazol-2-yl-phenyl)-thiophene-2-carboxylic acid ethyl ester



Obtain the title compound in the same reaction of Example E-86. Purify by flash chromatography (silica gel) eluting with hexanes-ethyl acetate 1:1 to obtain 0.148g. Mass spectrum ESI positive (m/z): 433 (M+1), 450 (M+18), 455 (M+23).

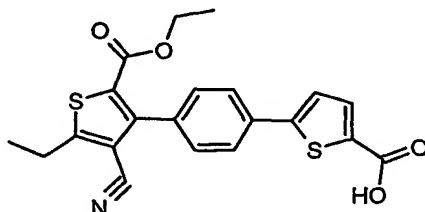
#### Example E-88

3-[4-(3-*tert*-Butoxycarbonylamino-thiophen-2-yl)phenyl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

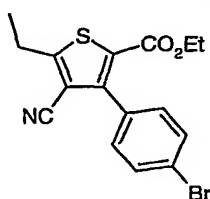


Prepare the title compound in a manner analogous to the procedure set forth in preparation of Example E-56 using material from Preparation 66 and stirring for 4h. Purify by flash chromatography (silica gel) eluting with hexanes-ethyl acetate gradient (10:1 to 1:1) to give 0.3 g of the title compound as a white solid. Mass spectrum ESI positive (m/z): 505 (M+23).

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Example E-893-[4-(5-Carboxy-thiophen-2-yl-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

- 5 Mix 4-cyano-5-ethyl-3-(4-bromo-phenyl)-thiophene-2-carboxylic acid ethyl ester (0.2 g, 0.55 mmol), 5-(dihydroxyboryl)-2-thiophene carboxylic acid (0.104 g, 1.0 mmol) and tetrakis(triphenylphosphine) palladium(0) (0.063 g, 0.05 mmol). Add DME (3 mL), ethanol (1.5 mL), 2M aqueous solution of sodium carbonate (0.55 mL) and stir at 90°C under nitrogen for 2h. Add ethyl acetate and 1M NaOH solution and separate phases.
- 10 Desired compound appears in both phases. Acidify organic and aqueous phases and concentrate them separately, to give 0.212 g of the title compound as beige solid. Mass spectrum ESI positive (m/z): 412 (M+1), 434 (M+23).

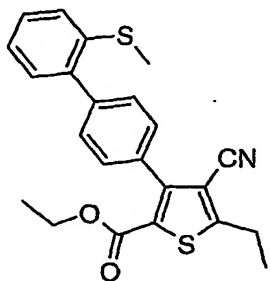
Example E-9015 3-(4-Bromo-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

- Add 4-cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester (268.1g, 0.8 mol) and 4-bromophenyl boronic acid (173.5g, 0.86 mol), to a solution of bis(tri-o-tolylphosphine)palladium (II) diacetate (7.00g, 0.008 mole) in acetonitrile(1.9 L) within a 5000 mL, 3-neck round-bottom flask equipped with an overhead stirrer, internal temperature probe, heating mantle, and a glycol-cooled condenser fitted with a nitrogen inlet. Add a solution of sodium carbonate (169.6g, 1.6 mol) in water (1.3 L) and stir the reactor contents at room temperature while sweeping the headspace with nitrogen for 10 min. Set the reaction apparatus for a nitrogen by-pass and heat the reaction mixture to 73°C.
- 25 C. Observe that HPLC analysis indicates substantial (> 98%) consumption of 4-

bromophenyl boronic acid and 4-cyano-5-ethyl-3-iodo-thiophene-2-carboxylic acid ethyl ester (flow rate: 1.5 mL/min; detection: 210 nm; mobile phase: isocratic 65/35 (v/v) acetonitrile / 0.1% trifluoroacetic acid in water; column: Zorbax® SB-Phenyl; 4.6 mm x 25 cm; 5 microns at 35 C). Cool the mixture to 23° C and separate the phases. Extract the aqueous phase twice with methyl t-butyl ether (300 mL). Combine the organic phases and concentrate under reduced pressure to an oil. Dissolve the oil in a mixture of heptane (500 mL) and methyl t-butyl ether (500 mL). This results in separation of an immiscible water phase. Separate, extract with methyl t-butyl ether the water phase (100 mL) and discard. Combine the organic phases and concentrate under reduced pressure to an oil.

10 Dissolve the oil in a mixture of heptane (500 mL) and methyl t-butyl ether (300 mL) and transfer the solution to a flask set for atmospheric distillation at 83° C. Continue the distillation until distillation at 83° C and atmospheric pressure stops. Cool the resulting solution to 30° C and seed with 3-(4-bromo-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester, and further cool the mixture to 18° C. Filter the resulting suspension and wash the filter cake with heptane (3 x 100 mL). Air-dry the resulting cake and transfer to a vacuum oven (40° C) to afford the title compound (263 g, 90.4 % yield). Additional purification as follows if desired for the title compound may be to add 3-(4-Bromo-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (367 g, 1.007 mol) and heptane (700 mL) to a 5000 mL, 3-neck round-bottom flask equipped with an overhead stirrer, internal temperature probe, and a nitrogen inlet. Stir the reactor contents at room temperature for 30 min. Filter the resulting suspension and rinse the filter cake with heptane (100 mL). Vacuum dry the resulting cake at 25° C, to afford 346.9 g (94.5% recovery) of additionally purified 3-(4-bromo-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (263 g, 90.4 % yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz): δ 7.58 (d, 2H, J=8.4); 7.29 (d, 2H, J=8.7); 4.21 (q, 2H, J=7.2); 3.09 (q, 2H, J=7.5); 1.43 (t, 3H, J=7.5); 1.22 (t, 3H, J=7.2).

25

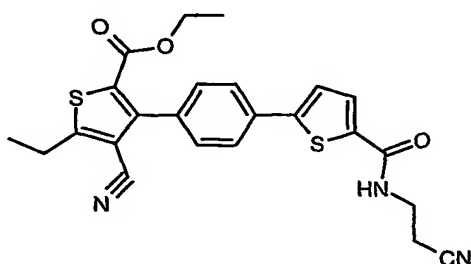
Example E-914-Cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

Combine potassium carbonate (54.4 g, 0.3937 moles, 2.1 eq) and water (1.32 L) in a 3 L 3-neck flask equipped with an overhead stirrer. Add 2-thiomethylphenyl boronic acid (34.65 g, 0.206 moles, 1.1 eq) to the resulting carbonate solution and stir about 15 minutes. Add Darco G-60 (7 g), and stir an additional 15 min at room temperature. Filter the suspension and add the filtrate to a 5 L 3-neck flask equipped with an overhead stirrer, heating mantle, thermocouple, condenser, and nitrogen inlet. Add palladium black 0.7 g (0.0658mol) and ethyl acetate (250 ml) and sweep the headspace with nitrogen for about 10 minutes. Add 4-cyano-5-ethyl-3-(4-bromo-phenyl)-thiophene-2-carboxylic acid ethyl ester (68.3 g, 0.1875 moles, 1.0 eq.) and ethyl acetate (250 ml) and stir the mixture to dissolve the 4-cyano-5-ethyl-3-(4-bromo-phenyl)-thiophene-2-carboxylic acid ethyl ester. Set the flask for a nitrogen by-pass through a bubbler and heat to reflux at 70.5 °C until substantial depletion of 4-cyano-5-ethyl-3-(4-bromo-phenyl)-thiophene-2-carboxylic acid ethyl ester. HPLC. (mobile phase = 27% 0.1% TFA in water, 73% ACN, 1.5 ml/min isocratic; Column = Zorbax SB-Phenyl 5um 4.6mm x 25cm at 35C; UV detection at 210 nm). Cool the mixture to 60 °C and filter to remove palladium black. Separate the phases and extract the aqueous phase with 100 ml ethyl acetate. Combine the organic phases and strip to a solid. Dissolve the solid in hot (75 °C) ethanol (600 ml) and transfer the resulting solution to a 1 L flask equipped with an overhead stirrer, condenser, and thermocouple. Cool the solution to 65 °C, seed with 4-cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester, and further cool to 18 °C. Filter the resulting precipitate and rinse with cool (10 °C) ethanol. Vacuum dry the solids at 50 °C, which affords the title compound (68.0 g, 89.0% yield). HPLC =

98.1%. (mobile phase = 27% 0.1% TFA in water, 73% ACN, 1.5 ml/min isocratic;  
Column = Zorbax SB-Phenyl 5um 4.6mm x 25cm at 35C; UV detection at 210 nm).

### Example E-92

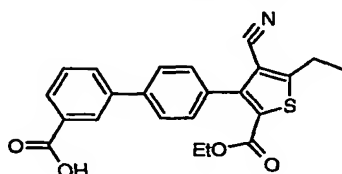
5 4-Cyano-3-{4-[5-(2-cyano-ethylcarbamoyl)-thiophen-2-yl]-phenyl}-5-ethyl thiophene-2-carboxylic acid ethyl ester



Add oxalyl chloride (0.011 mL) to a mixture of Example E-89 (0.042 g) and DMF (one drop) in dichloromethane (2 mL) at 0°C under nitrogen and stir at 0°C for 10 min,  
10 followed by stirring at 23°C for 5 min. Add more oxalyl chloride (0.003 mL) and stir until clear solution. Evaporate under a nitrogen flow and add dichloromethane (2 mL), followed by Et<sub>3</sub>N (0.048 g) and 3-aminopropionitrile, fumarate salt (0.022 g) at 0°C. Remove the cold bath and stir for 15 min. Add water and separate phases. Dry organic phase and concentrate in vacuo to give 0.016 g of desired product. <sup>1</sup>H NMR (acetone-d<sub>6</sub>,  
15 300 MHz) δ (ppm): 8.29 (t, J = 4.8 Hz, 1H); 7.84 (d, J = 8.5 Hz, 2H); 7.76 (d, J = 4.0 Hz, 1H); 7.59-7.55 (m, 3H); 4.20 (q, J = 7.1 Hz, 2H); 3.66 (q, J = 6.3 Hz, 2H); 3.14 (q, J = 7.5 Hz, 2H); 2.82 (t, J = 6.4 Hz, 2H); 1.43 (t, J = 7.7 Hz, 3H); 1.18 (t, J = 7.1 Hz, 3H).

### Example E-93

20 3-(3'-Carboxy-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester



Prepare the title compound in a manner analogous to the procedure set forth in general example A-9, step 1, using 3-carboxyphenyl boronic acid. To the crude reaction, add ethyl acetate, and wash thoroughly with 1M aqueous NaOH. Wash the combined

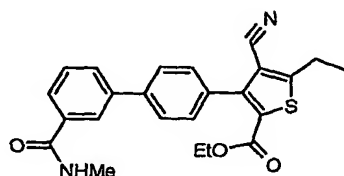
-155-

organic phase with ethyl acetate and acidify the aqueous layer with aqueous HCl and filter the solid that precipitates. Extract thoroughly the mother liquors and combine with the solid. Purify all the residue with a reverse phase HLB cartridge, to give 0.132 g of the desired compound. Mass spectrum ESI positive (m/z): 406 (M+1).

5

#### Example E-94

#### 4-Cyano-5-ethyl-3-(3'-methylcarbamoyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

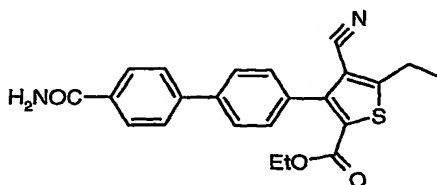


10 Prepare the title compound in a manner analogous to the procedure set forth in Example E-92, using 3-(3'-Carboxy-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester and methyl amine (2M THF solution). The crude residue obtained after aqueous work-up was used without further purification in the next step. Mass spectrum ESI positive (m/z): 419 (M+1).

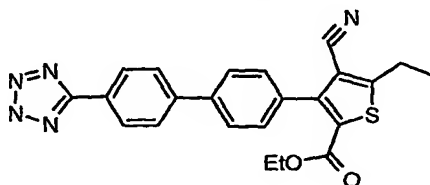
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#### Example E-95

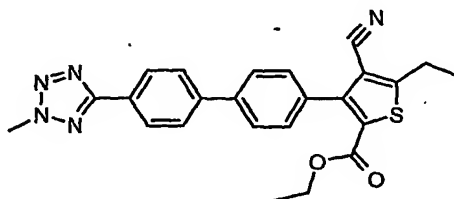
#### 3-(4'-Carbamoyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester



20 Prepare the title compound in a manner analogous to the procedure set forth in Example A-188, using material from Example E-15 (0.055 g) and 4-aminocarbonylphenyl boronic acid (0.026 g), to give 0.030 g of the desired product. Mass spectrum ESI positive (m/z): 405 (M+1).

Example E-964-Cyano-5-ethyl-3-[4'-(1(2)*H*-tetrazol-5-yl)-biphenyl-4-yl]-thiophene-2-carboxylic acid  
ethyl ester

5           Suspend sodium azide (0.039g) in acetonitrile (0.5 mL) and add silicon tetrachloride (1.0M solution in dichloromethane, 0.20 mL), followed by material from Example E-95 (0.088g) in acetonitrile (1.5 mL) and reflux the mixture under nitrogen overnight. Cool down, add ethyl acetate and water, and separate. Extract thoroughly the aqueous phase with ethyl acetate, dry the organic phase (anhydrous sodium sulfate) and  
10          evaporate over Celite®. Purify using a silica gel Strata® cartridge, to give 0.040 g of the title compound. Mass spectrum ESI negative (m/z): 428 (M-1).

Example E-974-Cyano-5-ethyl-3-[4'-(2-methyl-2*H*-tetrazol-5-yl)-biphenyl-4-yl]-thiophene-2-carboxylic  
15          acid ethyl ester

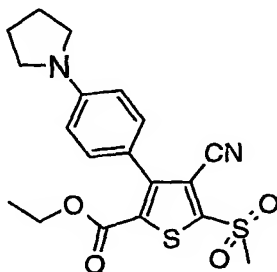
          Add methyl iodide (0.016 g) to a suspension of 4-cyano-5-ethyl-3-[4'-(1(2)*H*-tetrazol-5-yl)-biphenyl-4-yl]-thiophene-2-carboxylic acid ethyl ester (0.025 g) and cesium carbonate (0.019 g) in DMF (0.5 mL) and warm the mixture to 60°C for 1h. Add ethyl  
20          acetate and 1.2 M aqueous HCl and separate phases. Wash organic phase with more HCl and back-extract the aqueous layer with ethyl acetate. Dry combined organic phases (anhydrous sodium sulfate) and concentrate *in vacuo*. Purify using a silica gel Strata® cartridge eluting with hexanes-ethyl acetate gradient, to give the title compound as a white solid (0.0016 g), with a minor amount of the 1-methyl regioisomer. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300  
25          MHz) δ(ppm): 8.22 (d, J = 8.1 Hz, 2H); 7.85-7.72 (m, 4H); 7.53 (d, J = 8.1 Hz, 2H); 4.42



(s, 3H); 4.23 (q, J = 7 Hz, 2H); 3.11 (q, J = 7.5 Hz, 2H); 1.45 (t, J = 7.5 Hz, 3H); 1.23 (t, J = 6.7 Hz, 3H).

#### Example E-98

5     3-(4-Pyrrolidin-1-yl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester

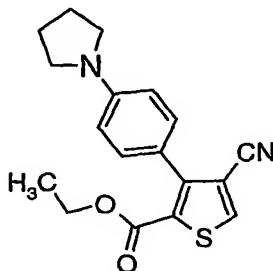


10     Add MCPBA (4.80g, 8.0 eq) to a solution of 3-(4-pyrrolidin-1-yl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (1 g, 2.7 mmol) in 40mL of CH<sub>2</sub>Cl<sub>2</sub> at 0°C. Remove the ice-bath and stir the reaction overnight. Wash the reaction mixture with water and brine. Dry over K<sub>2</sub>CO<sub>3</sub> and filter. Na<sub>2</sub>SO<sub>4</sub> (1 g) and CS<sub>2</sub> (excess 2 ml aprox) and stir at r.t. for 1 h. Monitor t.l.c. for lack of starting material (hex:AcOEt, 3:1). Filter the reaction mixture and evaporate the solvent to a solid which is used without further purification. Yield 82%. MS (ES<sup>+</sup>, m/e) = 405 (M<sup>+</sup>+1).

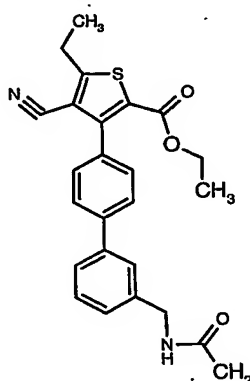
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#### Example E-99

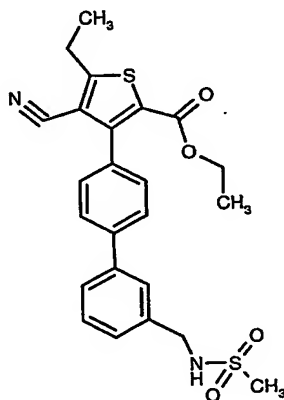
20     4-Cyano-3-(4-pyrrolidin-1-yl-phenyl)-thiophene-2-carboxylic acid ethyl ester



20     Prepare the title compound in a manner analogous to the procedure set forth in example E-50 using 3-(4-pyrrolidin-1-yl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester to provide the title compound. Mass spectrum (m/e): 327 (M+1).

Example E-1003-[3'-(Acetylamino-methyl)-biphenyl-4-yl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

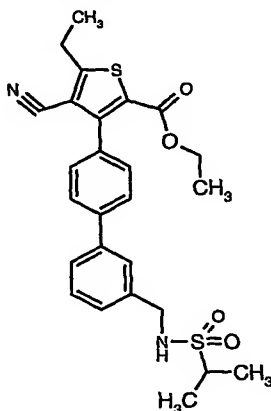
5 Add drop-wise acetyl chloride (1.2 equiv) to a solution of 3-(3'-aminomethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (1 equiv) (prepared following General example A-9, Step 1) and base 1.2 equiv of triethyl amine in dichloromethane at 0°C and allow to warm to room temperature. Stir 48 h and add 1.2 M  
10 aqueous HCl and separate phases. Evaporate solvent and purify by silica gel chromatography eluting with hexanes-ethyl acetate gradient.

Example E-1014-Cyano-5-ethyl-3-[3'-(methanesulfonylamino-methyl)-biphenyl-4-yl]-thiophene-2-carboxylic acid ethyl ester

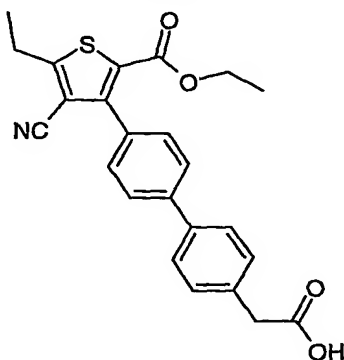
Add drop-wise methanesulfonyl chloride (1.2 equiv) to a solution of 3-(3'-aminomethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (1 equiv) (prepared following General example A-9, Step 1) and base (1.2 equiv of triethyl amine) in dichloromethane at 0°C and allow to warm to room temperature. Stir 48 h and  
5 add 1.2 M aqueous HCl and separate phases. Evaporate solvent and purify by silica gel chromatography eluting with hexanes-ethyl acetate gradient.

Example E-102

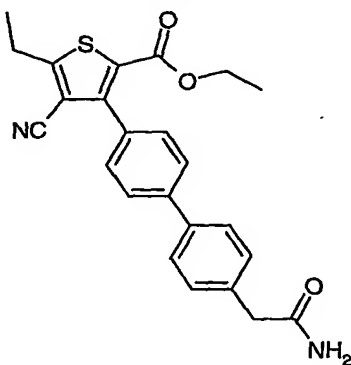
4-Cyano-5-ethyl-3-[3'-[(propane-2-sulfonylamino-methyl)-biphenyl-4-yl]-thiophene-2-  
10 carboxylic acid ethyl ester



Add drop-wise 2-propanesulfonyl chloride (1.2 equiv) to a solution of 3-(3'-aminomethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (1 equiv) (prepared following General example A-9, Step 1) and base (1.2 equiv of triethyl  
15 amine) in dichloromethane at 0°C and allow to warm to room temperature. Stir 48 h and add 1.2 M aqueous HCl and separate phases. Evaporate solvent and purify by silica gel chromatography eluting with hexanes-ethyl acetate gradient.

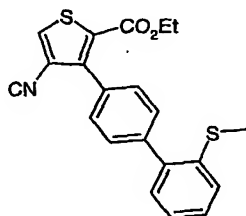
Example E-1033-(4'-Carboxymethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

5        Prepare the title compound in a manner analogous to the procedure set forth in General example A-10, using 3-(4-boronic acid-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (Example E-16) and (4-bromo-phenyl)-acetic acid (commercially available) as starting materials. Mass spectrum (m/e): 420 ( $M^+$ +1).

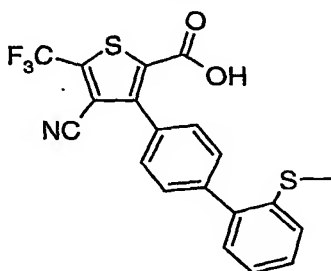
Example E-1043-(4'-Carbamoylmethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester

15        Prepare substantially in accordance with the procedure of 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid amide (Example AM-3) starting with 3-(4'-carboxymethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (quantitative yield). Mass spectrum (m/e): 419 ( $M^+$ +1).

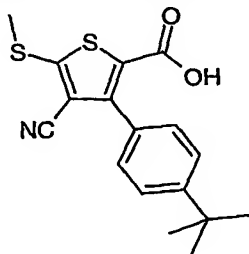
-161-

Example E-1054-Cyano-3-2-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

Follow general example A-9 (step 1) starting from 3-(4-iodophenyl)-4-cyano-  
5 thiophene-2-carboxylic acid ethyl ester.

Example A-14-Cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic acid

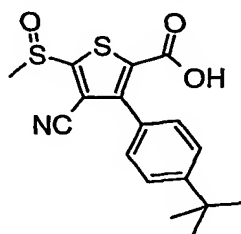
Using a method substantially in accordance with the method Example A-2, using  
4-cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic  
acid ethyl ester gives the title compound: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.57-7.20 (m,  
8H), 2.34 (s, 3H), <sup>19</sup>F NMR (CDCl<sub>3</sub>) δ -57.21 ppm (s), MS found (M-1) 418.

Example A-23-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid

Add NaOH 1M (1 ml) to a suspension of 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (general preparation 28, general preparation 29, general example E-1) (0.128 mmol) in ethanol (1 ml) and stir 24 h. Add 6N HCl until pH approx. 1 and white solid precipitates. Filter the solid to provide the title compound: MS (ES<sup>+</sup>, m/e): 332 (M+1).

### Example A-3

#### 3-(4-tert-Butyl-phenyl)-4-cyano-5-methanesulfinyl-thiophene-2-carboxylic acid



#### Step 1

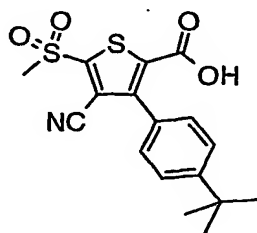
Prepare the ester of the title compound in a manner analogous to the procedure set forth in the example E-6, 3-(4-iodophenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester, using 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester as starting material and 1.0 equivalents of MCPBA.

#### Step 2

Prepare the title compound in a manner analogous to the procedure set forth in the example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid, to provide the title compound: Mass spectrum (m/e): 370.2 (M+23).

### Example A-4

#### 3-(4-tert-Butyl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid



#### Step 1

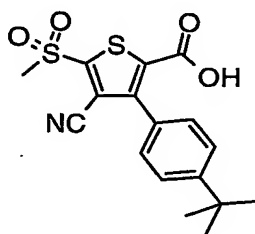
Prepare the ester of the title compound in a manner analogous to the procedure set forth in example E-6, 3-(4-iodophenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester, using the ethyl ester of 3-(4-tert-butyl-phenyl)-4-cyano-5-methane-thiophene-2-carboxylic acid as starting material and 1.5 equivalents of MCPBA

Step 2

Prepare the title compound in a manner analogous to the procedure set forth in example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfonyl-thiophene-2-carboxylic acid to provide the title compound: Mass spectrum (m/e): 386.2 (M+23).

Example A-5

3-(4-tert-Butyl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid

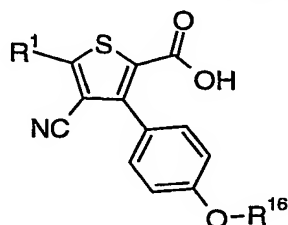


Step 1

Prepare the ester of the title compound in a manner analogous to the procedure set forth in example E-6, 3-(4-iodophenyl)-4-cyano-5-methanesulfonyl-thiophene-2-carboxylic acid ethyl ester, using 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfonyl-thiophene-2-carboxylic acid ethyl ester as starting material and 3.0 equivalents of MCPBA.

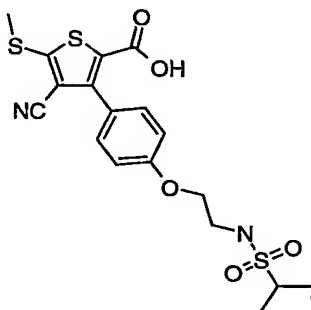
Step 2

Prepare the title compound in a manner analogous to the procedure set forth in example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfonyl-thiophene-2-carboxylic acid to provide the title compound: Mass spectrum (m/e): 386.2 (M+23).

General Example A-63-(4-OR<sup>16</sup>-phenyl)-4-cyano-5-R<sup>1</sup>-thiophene-2-carboxylic acid

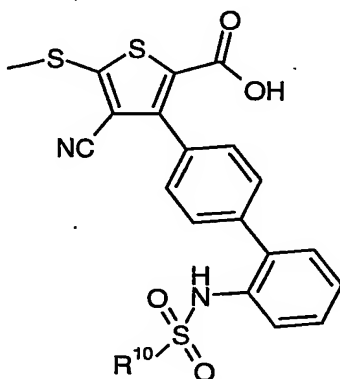
- 5 Prepare the title compound in a manner analogous to the hydrolysis procedure set forth in example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid using the analogous 3-(4-OR<sup>16</sup>-phenyl)-4-cyano-5-R<sup>1</sup>-thiophene-2-carboxylic acid ethyl ester.

10

Example A-74-Cyano-5-methylsulfanyl-3-{4-[2-(propane-2-sulfonylamino)-ethoxy]-phenyl}-thiophene-2-carboxylic acid

- 15 Prepare the title compound in a manner analogous to the hydrolysis procedure set forth in example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid: Mass spectrum (EI<sup>+</sup>): m/z 441 (M<sup>+</sup>+1); <sup>1</sup>H NMR (DMSO, 300 MHz): δ 7.29 (d, 2H, J= 8.5); 6.92 (d, 2H, J= 8.5); 3.96 (m, 1H); 2.71 (s, 3H); 2.64 (m, 2H); 2.18 (m, 2H); 1.15 (d, 6H, J= 6.9).



General Example A-84-Cyano-3-(2'-R<sup>10</sup> sulfonylamino-biphenyl-4-yl)-5-methylsulfanyl-thiophene-2-carboxylic acid

5

**Step 1**

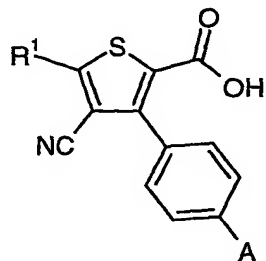
Add DBU (4.0 mmol) to a solution of 3-(2'-amino-biphenyl-4-yl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester in dichloromethane (5.0 mL)

- 10 followed by the corresponding sulfonyl chloride (1.0-2.0 mmol) added drop wise and stir at room temperature for 24h. Remove solvent under reduce pressure and purify the residue by silica and eluting with ethyl acetate:hexane to provide the title compound as ethyl ester. Obtain 3-(2'-amino-biphenyl-4-yl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester ) by using 2-nitrophenyl boronic acid and 3-(4-iodophenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester (example E-3) following
- 15 the procedure set forth Example A-9. Reduce the nitro group to the amino following the procedure set forth Scheme IV.

**Step 2**

Prepare the title compound compound in a manner analogous to the procedure set forth in example A-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid.

20

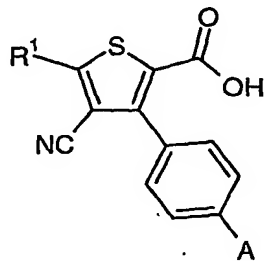
General Example A-94-Cyano-3-(4-A-phenyl)-5-R<sup>1</sup>-thiophene-2-carboxylic acid

## Step 1

- 5 Add 3-(4-X-phenyl)-4-Cyano-5-R<sup>1</sup>-thiophene-2-carboxylic acid ethyl ester (X= Br, I, OTf)(1.0mmol), the corresponding aryl boronic acid or the corresponding aryl tin or corresponding aryl zinc reagent (1.0-1.5 mmol), catalyst (0.05-0.10 mmol), and base (3-5 mmol) into solvent and heat to 60-100°C. After 1-18 hours cool to room temperature and add water. Extract with ethyl acetate. Combine the organics and wash with water and
- 10 brine, dry over sodium sulfate, filter and concentrate under reduced pressure. Purify by flash chromatography eluting with ethyl acetate:hexanes to provide the ester of the title compound.

## Step 2

- Prepare the title compound in a manner analogous to the procedure set forth in
- 15 Example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid.

General Example A-104-Cyano-3-(4-A-phenyl)-5-R<sup>1</sup>-thiophene-2-carboxylic acid

20

## Step 1

- Add the thiophene boronate (4-cyano-5-R<sup>1</sup>-3-[4-(4,4,5,5-tetramethyl-[1,3,2]dioxaborolan-2-yl)-phenyl]-thiophene-2-carboxylic acid ethyl ester), the thiophene

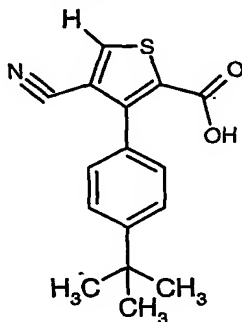
boronic acid (3-(4-boronic acid-phenyl)-4-cyano-5-R<sup>1</sup>-thiophene-2-carboxylic acid ethyl ester), or the thiophene trimethylstannyl-5-R<sup>1</sup>-3-(4-trimethylstannyl-phenyl)-thiophene-2-carboxylic acid ethyl ester) along with the corresponding aryl halide or corresponding aryl triflate as starting materials for the coupling as in example A-9 to provide the ester of the title compound.

#### Step 2

Prepare the title compound in a manner analogous to the procedure set forth in Example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid.

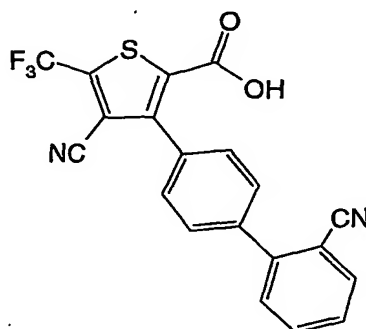
#### Example A-11

##### 3-(4-tert-Butyl-phenyl)-4-cyanothiophene-2-carboxylic acid

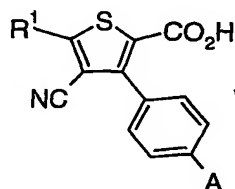


Add a solution of 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid (prepared in A-2) (0.633mmol) in methanol (5 mL) to a suspension of Na-Hg (7.7mmol) and Na<sub>2</sub>HPO<sub>4</sub> (2.55mmol) in methanol (10mL) and stir the reactions under nitrogen for 48 hours. Add NaOH (1%) and extract with methylene chloride (25 mL). Acidify aqueous phase with HCl and extract with methylene chloride (25 mL). Purify by flash chromatography (silica gel) eluting with hexane:ethyl acetate (1:5) to give 50mg (28% yield) of the title compound: <sup>1</sup>H-NMR (DMSO-d<sub>6</sub>) δ : 1.31 (s, 9H); 7.35 (m, 2H); 7.52 (m, 2H) 8.83 (s, 1H).

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Example A-124-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic acid

Using a method substantially in accordance with the method of example A-2,  
 5 starting with the compound from example 4-cyano-3-(2'-cyano-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic acid ethyl ester:  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.57-7.20 (m, 8H),  $^{19}\text{F}$  NMR ( $\text{CDCl}_3$ )  $\delta$  -57.21 ppm (s), MS found (M-1) 397.0 and (M+1) + $\text{NH}_3$  416.

General Example A-134-Cyano-3-(4-A-phenyl)-5- $\text{R}^1$ -thiophene-2-carboxylic acid

$\text{R}^1 = \text{SMe}, \text{Me}, \text{Et}, \text{iPr}, \text{CF}_3$

Step 1

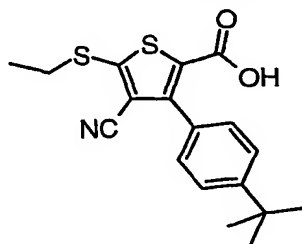
Add 3-iodo-4-Cyano-5- $\text{R}^1$ -thiophene-2-carboxylic acid ethyl ester (1.0mmol), the  
 15 corresponding phenyl boronic acid or the corresponding phenyl tin or zinc reagent (1.0-1.5 mmol), catalyst (0.05-0.10 mmol), and base (3-5 mmol) into solvent and heat to 60-100°C. After 1-18 hours cool to room temperature and add water. Extract with ethyl acetate. Combine the organics and wash with water and brine, dry over sodium sulfate, filter and concentrate under reduced pressure. Purify by flash chromatography eluting with  
 20 ethyl acetate:hexanes to provide the ester of the title compound.

Step 2

Prepare the title compound in a manner analogous to the procedure set forth in Example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid.

5 Example A-14

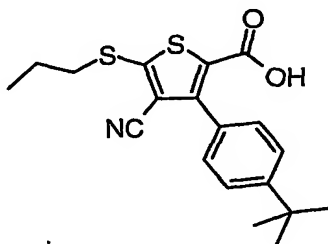
3-(4-tert-Butyl-phenyl)-4-cyano-5-ethylsulfanyl-thiophene-2-carboxylic acid



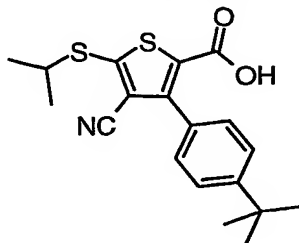
Prepare the title compound in a manner analogous to the procedure set forth in example A-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid, using 3-(4-tert-butyl-phenyl)-4-cyano-5-ethylsulfanyl-thiophene-2-carboxylic acid ethyl ester: Mass spectrum (m/e): 346 (M+1).

10 Example A-15

3-(4-tert-Butyl-phenyl)-4-cyano-5-propylsulfanyl-thiophene-2-carboxylic acid



15 Prepare the title compound in a manner analogous to the procedure set forth in example A-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid using 3-(4-tert-butyl-phenyl)-4-cyano-5-propylsulfanyl-thiophene-2-carboxylic acid ethyl ester: Mass spectrum (m/e): 360 (M+1).

Example A-15a3-(4-tert-Butyl-phenyl)-4-cyano-5-isopropylsulfanyl-thiophene-2-carboxylic acid

Prepare the title compound in a manner analogous to the procedure set forth in example A-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid using 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester: Mass spectrum (m/e): 360(M+1).

Prepare the carboxylic acids in Table A-1 following the procedure indicated. Esters are hydrolyzed following Example A-2.

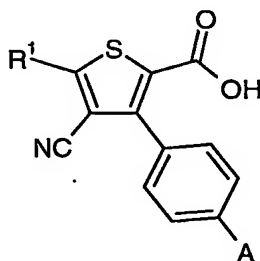


Table A-1

No.:	Procedure	R <sup>1</sup>	A	Data
A-16	general example A-13 or example E-27 and example A-2	F <sub>3</sub> C	Tert-butyl	mass spectrum (m/e): 352.1 (M-1).
A-17	general prep 29 and general example E-1	MeS	3,5-difluorophenyl	mass spectrum (m/e): 388.1 (M+1).
A-18	General Example A-9	MeS	2-fluorophenyl	mass spectrum (m/e): 370.1 (M+1).
A-19	General Example A-9	MeS	2-chlorophenyl	mass spectrum (m/e): 386.1 (M+1).
A-20	General Example A-9	MeS	2-methoxyphenyl	mass spectrum (m/e): 382.1 (M+1).
A-21	General Example	MeS	3-methoxyphenyl	mass spectrum

No.:	Procedure	R <sup>1</sup>	A	Data
	A-9			(m/e): 382.1 (M+1).
A-22	General Example A-9	MeS	4-fluorophenyl	mass spectrum (m/e): 370.1 (M+1).
A-23	General Example A-9	MeS	4-methoxyphenyl	mass spectrum (m/e): 382.1 (M+1).
A-24	General Example A-9	MeS	5-chloro-2-thienyl	mass spectrum (m/e): 392.1 (M+1).
A-25	General Example A-9	MeS	2,4-difluorophenyl	mass spectrum (m/e): 388.1 (M+1).
A-26	General Example A-9	MeS	2-trifluoromethylphenyl	mass spectrum (m/e): 420.1 (M+1).
A-27	General Example A-9	MeS	3,4-difluorophenyl	mass spectrum (m/e): 388.1 (M+1).
A-28	General Example A-9	MeS	3-fluorophenyl	mass spectrum (m/e): 370.1 (M+1).
A-29	General Example A-9	MeS	2,5-difluorophenyl	mass spectrum (m/e): 388.1 (M+1).
A-30	General Example A-9	MeS	3-benzothienyl	mass spectrum (m/e): 408.1 (M+1).
A-31	General Example A-9	MeS	2-thienyl	mass spectrum (m/e): 358.1 (M+1).
A-32	General Example A-9	MeS	3-thienyl	mass spectrum (m/e): 358.1 (M+1).
A-33	General Example A-9	MeS	2,3-difluorophenyl	mass spectrum (m/e): 388.1 (M+1).
A-34	General Example A-9	MeS	3-trifluoromethylphenyl	mass spectrum (m/e): 420.1 (M+1).
A-35	General Example A-9 using Boc protected 2H-pyrrole followed by deprotection	MeS	2H-pyrrole	mass spectrum (m/e): 341.1 (M+1).
A-36	General Example A-9	MeS	2-ethoxyphenyl	mass spectrum (m/e): 396.1 (M+1).
A-37	General Example A-9	MeS	3-ethoxyphenyl	mass spectrum (m/e): 396.1 (M+1).
A-38	General Example A-9	MeS	4-ethoxyphenyl	mass spectrum (m/e): 396.1 (M+1).

No.:	Procedure	R <sup>1</sup>	A	Data
A-39	General Example A-9	MeS	2-methoxy-5-fluorophenyl	mass spectrum (m/e): 400.1 (M+1).
A-40	A-35 and Example E-47	MeS	N-methyl-2-pyrrole	mass spectrum (m/e): 355.1 (M+1).
A-41	A-61	MeS	N-acetyl-2-pyrrole	mass spectrum (m/e): 383.1 (M+1).
A-42	General Example A-9	MeS	2-tolyl	mass spectrum (m/e): 366.1 (M+1).
A-43	General Example A-9	MeS	2-fluoro-6-methoxyphenyl	mass spectrum (m/e): 400.1 (M+1).
A-44	General Example A-9	MeS	2-nitrophenyl	mass spectrum (m/e): 397.1 (M+1).
A-45	General Example A-9	Ethyl	2-fluorophenyl	mass spectrum (m/e): 350.1 (M-1).
A-46	General Preparation 30, 31, 32, 29 General Example E-1	MeS	piperidin-1-yl	mass spectrum (m/e): 359 (M+1).
A-47	General Preparation 32, 29 and general example E-1	MeS	pyrrolidin-1-yl	mass spectrum (m/e): 345 (M+1).
A-48	Example E-10	Ethyl	pyrrolidin-1-yl	mass spectrum (m/e): 327 (M+1).
A-49	Example E-5 and Example E-62	MeS	-NH(SO <sub>2</sub> )CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>	mass spectrum (m/e): 443 (M-1).
A-50	Example E-64	MeS	dimethylamino	mass spectrum (m/e): 319 (M+1).
A-51	Example E-63	MeS	cyclohexylamino	mass spectrum (m/e): 373 (M+1).
A-52	Example A-171 and Example A-173	MeS	-CONH(CH <sub>2</sub> ) <sub>2</sub> .NHSO <sub>2</sub> iPr	mass spectrum (m/e): 466 (M-1).
A-54	General Prep 28, 29, 33 and general Example E-2	Me <sub>2</sub> N	tert-butyl	mass spectrum (m/e): 329 (M+1).
A-55	General Prep 29, 33 and general example E-2	Me <sub>2</sub> N	pyrrolidin-1-yl	mass spectrum (m/e): 342 (M+1).

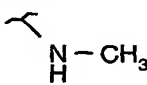
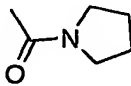
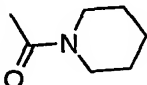


No.:	Procedure	R <sup>1</sup>	A	Data
A-56	general prep 28, 29 and general example E-1	MeS	cyclopentyl	mass spectrum (m/e): 342 (M-1).
A-57	preparation 4 and general example A-13	Ethyl	cyclopentyl	mass spectrum (m/e): 324 (M-1).
A-58	preparation 4, general example A-13, example E-37, E-38, E-39	Me <sub>2</sub> N	cyclopentyl	mass spectrum (m/e): 341 (M+1).
A-59	Preparation 6 and general example A-13	Ethyl	2-cyanoethyl	mass spectrum (m/e): 311 (M+1).
A-60	General Example A-9	Ethyl	2-methylthiophenyl	mass spectrum (m/e): 378 (M-1).
A-61	General Example A-9 Example E-45	Ethyl	2-methoxyphenyl	mass spectrum (m/e): 318 (M-COOH).
A-62	General Example A-9 Example E-46	Ethyl	2-ethoxyphenyl	mass spectrum (m/e): 376 (M-1).
A-63	General Example A-9 Example E-47	Ethyl	2-(n-propoxy)phenyl	mass spectrum (m/e): 390 (M-1).
A-64	General Example A-9 Example E-48	Ethyl	2-isopropoxyphenyl	mass spectrum (m/e): 390 (M-1).
A-65	General Example A-9 Example E-45	Ethyl	2-hydroxyphenyl	mass spectrum (m/e): 348 (M-1).
A-66	Preparation 2 Example E-37	MeS	2-cyanophenyl	mass spectrum (m/e): 375 (M-1).
A-67	Preparation 2 Example E-42	Ethyl	2-cyanophenyl	mass spectrum (m/e): 313 (M-COOH).
A-68	Preparation 2 Example E-39	Me <sub>2</sub> N	2-cyanophenyl	mass spectrum (m/e): 372(M-1).
A-69	Preparation 2 Example E-50	H	2-cyanophenyl	mass spectrum (m/e): 329(M-1).
A-70	Example E-41	Ethyl	tert-butyl	mass spectrum (m/e): 312 (M-1).
A-71	General Example A-9	MeS	thiazol-2-yl	mass spectrum (m/e): 359 (M+1).

No.:	Procedure	R <sup>1</sup>	A	Data
A-72	General Example A-9	Ethyl	thiazol-2-yl	mass spectrum (m/e): 341 (M+1).
A-73	General Example A-9	Me <sub>2</sub> N	thiophen-2-yl	mass spectrum (m/e): 355 (M+1).
A-74	General Example A-9	Ethyl	thiophen-2-yl	mass spectrum (m/e): 338 (M-1).
A-75	General Example A-9	Ethyl	thiophen-3-yl	mass spectrum (m/e): 338 (M-1).
A-76	General Example A-9	Ethyl	3-cyanothiophen-2-yl	mass spectrum (m/e): 319 (M-COOH).
A-77	General Example A-9	Ethyl	4-cyanothiophen-3-yl	mass spectrum (m/e): 319 (M-COOH).
A-78	General Example A-9	Ethyl	2-cyanothiophen-3-yl	mass spectrum (m/e): 319 (M-COOH).
A-79	General Example A-9	Ethyl	3-nitrothiophen-2-yl	mass spectrum (m/e): 339 (M-COOH).
A-80	General Example A-9 and E-5	Ethyl	3-aminothiophen-2-yl	mass spectrum (m/e): 309 (M-COOH).
A-81	General Example A-9 and E-81	Ethyl	3-dimethylamino-thiophen-2-yl	mass spectrum (m/e): 337 (M-COOH).
A-83	general prep 28,29 general example E-1	MeS	2-aminophenyl	mass spectrum (m/e): 367 (M+1).
A-84	Example A-8	MeS	2-(Methylsulfonylamino)phenyl	mass spectrum (m/e): 445 (M+1).
A-85	Example A-8	MeS	2-(propane-2-sulfonylamino)phenyl	mass spectrum (m/e): 473 (M+1).
A-86	Prep 34, 35, 36, 7, 8, 9 10 and general example A-13	Ethyl	2-(propane-2-sulfonylamino)phenyl	mass spectrum (m/e): 453 (M-1).
A-87	Example A-9 Example A-8	Me <sub>2</sub> N	2-(propane-2-sulfonylamino)phenyl	mass spectrum (m/e): 470 (M+1).
A-88	General Example E-17-A	MeS	benzyloxy	mass spectrum (EI+): 382 (M+1).
A-89	General Example E-17-A	Ethyl	benzyloxy	mass spectrum (EI+):

No.:	Procedure	R <sup>1</sup>	A	Data
				364 (M+1).
A-90	General Example E-17-A	MeS	Pyridin-2-yloxy	mass spectrum (EI+): 369 (M+1).
A-91	General Example E-17-C	MeS	2-cyanophenoxy	mass spectrum (EI+): 393 (M+1).
A-92	General Example E-17-A	Ethyl	2-cyanophenoxy	mass spectrum (EI+): 375 (M+1).
A-93	General Example E-17-A	Ethyl	2-cyanophenylmethoxy	mass spectrum (EI+): 387 (M+1).
A-94	General Example E-17-A	Ethyl	2-methoxyethoxy	mass spectrum (EI+): 332 (M+1).
A-95	General Example E-17-C	MeS	4-fluorophenoxy	mass spectrum (EI+): 386 (M+1).
A-97	General Example E-17-B	MeS	cyclohexyloxy	mass spectrum (EI+): 374 (M+1).
A-98	General Example E-17-B	MeS	cyclopentyloxy	mass spectrum (EI+): 360 (M+1).
A-99	General Example E-17-B	MeS	phenethyloxy	mass spectrum (EI+): 396 (M+1).
A-99A	General Example E-17-B	Ethyl	pyridin-2-ylmethoxy	mass spectrum (EI+): 365 (M+1).
A-99B	General Example E-17-B	Ethyl	2-methylsulfanylethoxy	mass spectrum (EI+): 348 (M+1).
A-100	General Prep 27, 28, 29 General Example E1	MeS	phenoxy	mass spectrum (EI+): 368 (M+1).
A-101	General prep 28, 29 General Example E1	MeS	Phenyl	mass spectrum (m/e): 352.1 (M+1).
A-102	General prep 27, 28, 29 General Example E1	MeS	isopropyl	mass spectrum (m/e): 318.1 (M+1).
A-103	General prep 27, 28, 29 General Example E1	MeS	acetyl	mass spectrum (m/e): 318.1 (M+1).
A-104	General prep 27, 28, 29	MeS	cyano	mass spectrum (m/e): 301.1 (M+1).

No.:	Procedure	R <sup>1</sup>	A	Data
	General Example E1			
A-105	General prep 28, 29, General Example E1, Example A-171, and Example A-173	MeS	-CONH i-Pr	mass spectrum (m/e): 361.1 (M+1).
A-106	General prep 28, 29 General Example E1, E5 and Example E-61	MeS	-NHCOMe	mass spectrum (m/e): 333.1 (M+1).
A-107	General prep 28, 29 General Example E1, E5 and Example E-61	MeS	-NHCO i-Pr	mass spectrum (m/e): 361.1 (M+1).
A-108	General prep 28, 29 General Example E1, E5 and Example E-61	MeS	-NHCOPhenyl	mass spectrum (m/e): 395.2 (M+1).
A-109	General prep 28, 29 General Example E1	MeS	iodo	mass spectrum (m/e): 402.1 (M+1).
A-110	General prep 28, 29 General Example E1 and Example E-63	MeS	Methylsulfonylamino	mass spectrum (m/e): 369.1 (M+1).
A-111	General prep 28, 29 General Example E1 and Example E-65	MeS	vinyl	mass spectrum (m/e): 302.1 (M+1).
A-112	General prep 28, 29 General Example E1, E5 and Example E-63	MeS	Benzylamino	mass spectrum (m/e): 381.1 (M+1).

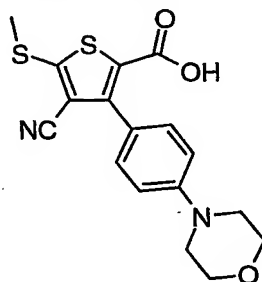
No.:	Procedure	R <sup>1</sup>	A	Data
A-113	General prep 28, 29 General Example E1, E5 and Example E-64	MeS	Methylamino 	mass spectrum (m/e): 305.1 (M+1).
A-114	General prep 28, 29 General Example E1, A9	MeS	3-chlorophenyl	mass spectrum (m/e): 386.2 (M+1).
A-115	General prep 28, 29 General Example E1, A9	MeS	3-trifluoromethoxy phenyl	mass spectrum (m/e): 382.1 (M+1).
A-116	General prep 28, 29 General Example E1, A9	MeS	4-chlorophenyl	mass spectrum (m/e): 386.2 (M+1).
A-117	General prep 28, 29 General Example E1, A9	MeS	5-acetyl-2-thienyl	mass spectrum (m/e): 400.1 (M+1).
A-118	General prep 28, 29 General Example E1	MeS		mass spectrum (m/e): 373.1 (M+1).
A-119	General prep 28, 29 General Example E1	MeS		mass spectrum (m/e): 387.1 (M+1).
A-120	General prep 28, 29 General Example E1, A9	MeS	4-trifluoro methylphenyl	mass spectrum (m/e): 420.1 (M+1).
A-121	A-35 and Example E-47	MeS	N-ethyl-2-pyrrole	mass spectrum (m/e): 369.1 (M+1).
A-122	General Example A9	Me <sub>2</sub> N	2-nitrophenyl	mass spectrum (m/e): 394.1 (M+1).
A-123	General prep 28, 29 General Example E1	Ethyl	ethyl	mass spectrum (m/e): 286.1 (M+1).
A-124	Example E-16	Ethyl	4-Cyano-5-ethyl-thiophene-2-carboxylic acid-3-yl	mass spectrum (EI+): 437 (M+1).
A-125	General Example	Ethyl	3-methoxy-pyridin-2-yl	mass spectrum

No.:	Procedure	R <sup>1</sup>	A	Data
	A-10			(EI+): 365 (M+1).
A-126	General Example A-10	Ethyl	Pyrimidin-2-yl	mass spectrum (EI+): 336 (M+1).
A-127	General Example A-10	Ethyl	3-cyano-pyridin-2-yl	mass spectrum (EI+): 360 (M+1).
A-128	General Example A-10	Ethyl	Pyrimidin-5-yl	mass spectrum (EI+): 336 (M+1).
A-130	general example 13	Methyl	3-methylthio-thiophene-2-yl	mass spectrum (EI+): 372 (M+1).
A-131	General example A-9	Ethyl	Pyridin-5-yl	
A-133	General Example A-9	Ethyl	Pyridin-2-yl	mass spectrum (EI+): 335 (M+1).
A-134	General Example A-10 and preparation 57	Ethyl	3-(propane-2-sulfonylamino)-pyridine-2-yl	mass spectrum (EI+): 456 (M+1).
A-135	General Example A-10 and preparation 58	Ethyl	6-(propane-2-sulfonylamino)-pyridine-2-yl	mass spectrum (EI+): 456 (M+1).
A-136	General Example A-9	Ethyl	3-thiomethylthiophen-2-yl	mass spectrum (m/e): 340 (M-COOH).
A-137	General Example A-10	Ethyl	3-chlorothiophen-2-yl	mass spectrum (m/e): 328 (M-COOH).
A-138	Example A-9 and Example E-82	Ethyl	3-(methyl-butyl amino)-thiophen-2-yl	mass spectrum (m/e): 425 (M+1).
A-139	Example A-9 and Example E-83	Ethyl	3-isobutyl amino-thiophen-2-yl	mass spectrum (m/e): 411 (M+1).
A-140	General Example A-9	Ethyl	4-(3-carbamoyl-thiophen-2-yl)	mass spectrum (m/e): 383 (M+1).
A-140b	General example A-10 and example E-16	Ethyl	2-cyano-4-fluoro-phenyl	mass spectrum (m/e): 377(M <sup>+</sup> +1).
A-140c	General example A-10 and example E-16 and preparation 67	Ethyl	4-acetyl-2-cyano-phenyl	mass spectrum (m/e): 401(M <sup>+</sup> +1).
A-140d	General example A-10 (step 1) and preparation 71 and preparation	Ethyl	2,4-dicyano-phenyl	mass spectrum (m/e): 384(M <sup>+</sup> +1).

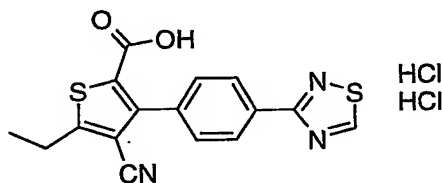
No.:	Procedure	R <sup>1</sup>	A	Data
	69			
A-140e	General example A-10 (step 1) and preparation 71	Ethyl	3-fluoro-4-methoxy-phenyl	mass spectrum (m/e): 382(M <sup>+</sup> +1).
A-140f	General example A-10 (step 1) and preparation 71	Ethyl	4-cyano-3-fluoro-phenyl	mass spectrum (m/e): 377(M <sup>+</sup> +1).
A-140h	General example A-10 (step 1) and preparation 71	Ethyl	4[(2-propane-2-sulfonylamino)ethyl]-phenyl	mass spectrum (m/e): 483(M <sup>+</sup> +1).
A-140i	General example A-10 and example A-150 and preparation 6	Ethyl	4-(2-cyanoethyl)-phenyl	mass spectrum (m/e): 387(M <sup>+</sup> +1).
A-140j	General example A-10 (step 1) and preparation 71	Ethyl	4-cyano-phenyl	mass spectrum (m/e): (ESI negative) 313(M <sup>+</sup> -45).
A-140k	General example A-10 (step 1) and preparation 71 and preparation 70	Ethyl	3-methylsulfamoyl-phenyl	mass spectrum (m/e): 427(M <sup>+</sup> +1)
A-140l	General example A-10 (step 1) and preparation 71	Ethyl	4-benzofuran-5-yl	mass spectrum (m/e): (ESI negative) 328(M <sup>+</sup> -45).
A-140m	General example A-10 and example E-16	Ethyl	4-amino-2-cyano-phenyl	mass spectrum (m/e): 374(M <sup>+</sup> +1).
A-140o	General example A-10 (step 1) and preparation 71	Ethyl	4-sulfamoyl-phenyl	mass spectrum (m/e): 413(M <sup>+</sup> +1).
A-140p	General example A-10 (step 1) and preparation 71	Ethyl	3-sulfamoyl-phenyl	mass spectrum (m/e): 413(M <sup>+</sup> +1).
A-140q	General Example A-9	Et	4-(2-hydroxyethyl)phenyl	mass spectrum (m/e): 378(M+1).
A-140r	General Example A-9	Et	3-CH <sub>2</sub> NH <sub>2</sub> HCl	mass spectrum (m/e): 363 (M+1).
A-140s	General Example A-9	Et	2-methylsulfanyl-thiazol-4-yl	mass spectrum (m/e): 387 (M+1).
A-140t	General Example A-9	Et	3-acetylamino-methyl	mass spectrum (m/e): 405 (M+1).

No.:	Procedure	R <sup>1</sup>	A	Data
A-140u	General Example A-9	Et	3-methanesulfonylamino-methyl	mass spectrum (m/e): 463 (M+23).
A-140v	General Example A-9	Et	3-(propane-2-sulfonylamino)-methyl	mass spectrum (m/e): 491 (M+23).
A-140w	General Example A-10, step 1 using preparation 71	Et	4-cyanomethyl-2-methoxy-phenyl	mass spectrum (m/e): 403 (M+1).
A-140x	General Example A-10, step 1 using preparation 71	Et	4-cyanomethyl-2-ethoxy-phenyl	mass spectrum (m/e): 417 (M+1).
A-141	General example E-17-B	Ethyl	3-carboxamidebenzyloxy	Mass spectrum (m/e). 407 (M+1)
A-141b	General example A-10 and preparation E-16	Ethyl	pyrazin-2-yl	mass spectrum (m/e): 336 (M <sup>+</sup> +1).
A-141c	General example A-10 and preparation E-51	Iso-propyl	2-methylthio-phenyl	mass spectrum (m/e): 394 (M <sup>+</sup> +1).
A-142	General example A-10 and preparation E-16	Ethyl	2-cyano-4-nitrophenyl	mass spectrum (m/e): 404 (M <sup>+</sup> +1).
A-143	General example A-10 and preparation E-16	Ethyl	2-cyano-4-hydroxy-phenyl	mass spectrum (m/e): 375 (M <sup>+</sup> +1).
A-143A	General example A-10 (step 1) and preparation 71	Ethyl	(1-oxo-indan-5-yl)-phenyl	mass spectrum (m/e): 388(M <sup>+</sup> +1).
A-143B	General example A-10 (step 1) and preparation 71	Ethyl	4-(2-oxo-pyrrolidin-1-yl)-phenyl	mass spectrum (m/e): 417(M <sup>+</sup> +1).
A-143C	General example A-10 and example E-16	Ethyl	Quinolin-6-yl	mass spectrum (m/e): 385(M <sup>+</sup> +1).



4-Cyano-5-methylsulfanyl-3-(4-morpholin-4-yl-phenyl)-thiophene-2-carboxylic acid

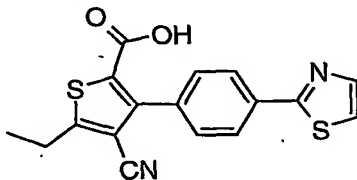
Prepare the title compound in a manner analogous to the procedure set forth in example A-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid using 4-Cyano-5-methylsulfanyl-3-(4-morpholin-4-yl-phenyl)-thiophene-2-carboxylic acid ethyl ester: Mass spectrum (m/e): 361(M+1).

Example A-1454-Cyano-5-ethyl-3-(4-[1,2,4]-thiadiazol-2-yl-phenyl)-thiophene-2-carboxylic acid dihydrochloride

Dissolve 4-cyano-5-ethyl-3-(4-[1,2,4]-thiadiazol-2-yl-phenyl)-thiophene-2-carboxylic acid diethyl ester (0.030 g, 0.08mmol) in THF (2 mL), add sodium hydroxide (1M aqueous solution, 2 mL) and stir the mixture overnight at 23°C. Next day add more THF (1mL), sodium hydroxide (1mL) and ethanol (2 mL) and stir 1.5 d at 23°C, until no starting material is left. Separate phases, wash aqueous layer with ethyl acetate and separate. Acidify aqueous phase with 3M HCl and allow to precipitate overnight. Filter to obtain 0.015 g (55%) of the title compound as a white solid. Mass spectrum ESI positive (m/z): 342 (M+1).

Example A-146

Additional preparation of 4-Cyano-5-ethyl-3-(4-thiazol-2-yl-phenyl)-thiophene-2-carboxylic acid (see example A-72)

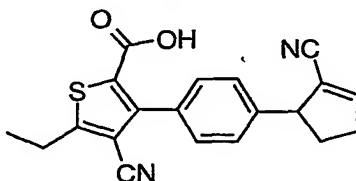


5        Add ethanol (5 mL) to 4-cyano-5-ethyl-3-(4-thiazol-2-yl-phenyl)-thiophene-2-carboxylic acid ethyl ester (0.80 mmol.) and then 2.5 M aqueous solution of LiOH (2.5 mL) and stir while heating at 60°C for 1 h. Cool down, add HCl and extract with CHCl<sub>3</sub>-ethyl acetate. Purify by SCX cartridges to give 0.261 g of the title compound as a white solid. mass spectrum ESI positive (m/z) 341 (M + 1).

10

Example A-147

(R,S) 4-Cyano-3[4-(2-cyano-cyclopent-2-enyl)-phenyl]- 5-ethyl-thiophene-2-carboxylic acid

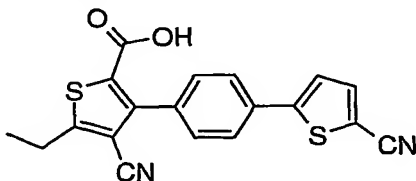


15        Starting with (R,S) 4-Cyano-3-[4-(2-cyano-cyclopent-2-enyl)-phenyl]- 5-ethyl-thiophene-2-carboxylic acid ester, prepare the title compound in a manner analogous to the procedure set forth in preparation of Example A-145, using ethanol instead of tetrahydrofuran: mass spectrum ESI positive (m/z) 366 (M+18), 371 (M+23).

20

Example A-148

4-Cyano-3-[4-(5-cyano-thiophen-2-yl-phenyl)-5-ethyl thiophene-2-carboxylic acid

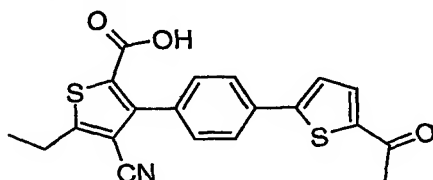


-183-

Add NaOH (1mL) to a suspension of 4-cyano-3-[4-(5-cyano-thiophen-2-yl-phenyl)-5-ethyl thiophene-2-carboxylic acid ethyl ester in ethanol (1.5mL) and stir at 60°C for 10 min. Evaporate ethanol, add TFA (0.3 mL) and concentrate in vacuo. Suspend the residue in water, heat to 80°C for 10 min and filter. Purify the solid using SPE Strata® silica gel cartridge eluting successively with ethyl acetate; ethyl acetate: MeOH 20:1; ethyl acetate: TFA 50:0.1. Suspend the solid in ethyl acetate and filter to obtain 0.12 g of the title compound as an off-white solid. <sup>1</sup>H NMR (d6-acetone/d4-methanol (5.:1), 300 MHz)  $\delta$ : 7.72 (d, J = 8.1Hz, 2H), 7.66 (d, J = 4.0 Hz, 1H), 7.47 (d, J = 4.0 Hz, 1H), 7.46 (d, J = 8.1 Hz, 2H), 3.04 (q, J = 7.4 Hz, 2H), 1.33 (t, J = 7.5 Hz, 3H).

#### Example A-149

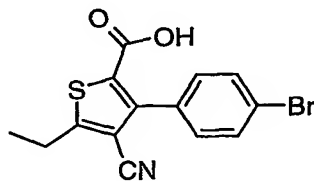
##### 3-[4-5-Acetyl-thiophen-2-yl)-phenyl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid



Prepare the title compound in a manner analogous to the procedure set forth in Example A-148, using 3-[4-5-acetyl-thiophen-2-yl)-phenyl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester and 2.5M aqueous solution of LiOH, stirring 15 min. Purify by reverse phase HPLC (using acetonitrile as organic solvent at pH about 2.5 (TFA 0.05%) to give 0.02 g of the title compound as beige solid. Mass spectrum ESI positive (m/z): 382 (M+1).

#### Example A-150

##### 3-(4-(Bromophenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid

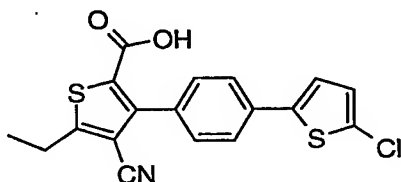


Add ethanol (50ml) and 1M aqueous solution of NaOH to 3-(4-(bromophenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (5.0 g, 13.73 mmol) and stir at 60°C for 1h. Cool down and acidify with 3M HCl until white solid precipitates. Filter and wash

solid with water and hexanes successively. Dry overnight to give 4.34 g as a white solid. Mass spectrum ESI positive (m/z): 366 (M+1).

Example A-151

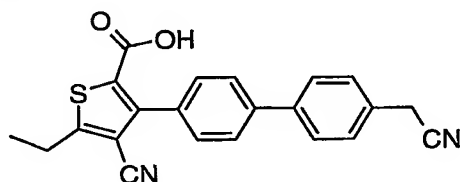
5     3-[4-(5-(Chlorothiophen-2-yl)-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid



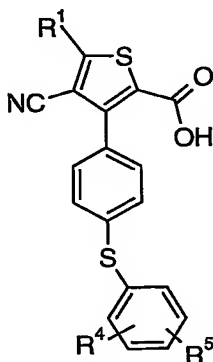
Mix 3-(4-(bromophenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid (0.2 g, 0.59 mmol), 5-chloro-2-thiophen boronic acid (0.134 g, 0.82 mmol), tetrakis(triphenylphosphine)palladium(0) (0.063 g, 0.055 mmol) and 2M aqueous solution of sodium carbonate (0.55 mL) in DME (2 mL) and ethanol (1 mL). Bubble with nitrogen and stir at 90°C in a sealed tube for 1.5h. Add more 5-chloro-2-thiophen boronic acid (0.015 g) and tetrakis(triphenylphosphine)palladium(0) (0.025 g) and stir at 90°C 3 h. Remove ethanol in vacuo, add TFA (0.3 mL) and filter through a silica gel cartridge. Concentrate the filtrate over Celite® and purify in SPE Strata® cartridges (silica gel) eluting with hexanes/TFA (0.05%)-isopropanol gradient (isopropanol from 2% to 30%). Final purification achieved by reverse phase HPLC (TFA 0.05% at pH 2.5, acetonitrile as organic solvent). Mass spectrum ESI positive (m/z): 374 (M+1), 396 (M+23).

Example A-151 A

20     4-Cyano-3-(4'-cyanomethyl-biphenyl-4-yl)-5-ethyl-thiophene-2-carboxylic acid

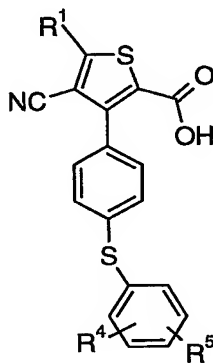


Prepare the title compound in a manner analogous to the procedure set forth in preparation of Example A-151 using 4-cyanomethylphenyl boronic acid. Purify following procedure Example A-151 and recrystallize from acetone to give 0.052 g as a white powder. Mass spectrum ESI positive (m/z): 373 (M+1), 395 (M+23).

General Example A-1524-Cyano-5-R<sup>1</sup>-3-(4-mercapto-R<sup>4</sup>,R<sup>5</sup>-phenyl)-thiophene-2-carboxylic acid

5        Add LiOH (2.5 M aqueous solution, 2 mL) to an ethanol (2 mL) solution of thioether and warm at 40°C for 10 min. Cool down and acidify with 1.2 M HCl. Add ethyl acetate (2 x 3mL) and chloroform (3 mL) and separate phases. Filter through a short plug of silica gel, concentrate over Celite® and purify using SPE Strata® cartridges (silica gel). Recrystallize from acetone or ethyl acetate.

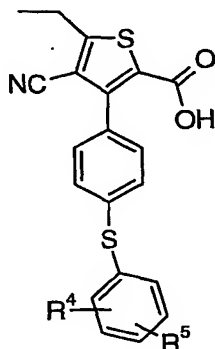
10

General Example A-152A4-Cyano-5-R<sup>1</sup>-3-(4-mercapto-R<sup>4</sup>,R<sup>5</sup>-phenyl)-thiophene-2-carboxylic acid

15        Add LiOH (2.5 M aqueous solution, 2 mL) to a THF (2 mL) solution of thioether (general example E-68 and general example E-69) and warm at 60°C for 3h. Cool down and acidify with 1.2 M HCl. Add ethyl acetate (2 x 3mL) and chloroform (3 mL) and separate phases. Filter through a short plug of silica gel, concentrate over Celite® and

purify using SPE Strata® cartridges (silica gel). Recrystallize from acetone or ethyl acetate.

By using a method similar to the general example A-152 and A-152A, the following compounds can be synthesized as set forth in Table A-2:



5

Table A-2

In the following examples R<sup>5</sup> is hydrogen

No.	R <sup>4</sup>	Method	Data
A-153	2-methoxy	A-152A	Mass spectrum (m/z): 396(M+1), 418(M+23)
A-154	H	A-152A	Mass spectrum (m/z): 366(M+1), 388(M+23)
A-155	2-chloro	A-152A	Mass spectrum (m/z): 398(M-1), 345(M-44)
A-156	3-chloro	A-152A	Mass spectrum (m/z): 398(M-1), 354(M-45)
A-157	4-chloro	A-152A	Mass spectrum (m/z): 398(M-1), 345(M-44)
A-158	3-methoxy	A-152A	Mass spectrum (m/z): 396(M+1), 418(M+23)
A-159	4-methoxy	A-152A	Mass spectrum (m/z): 396(M+1), 418(M+23)
A-160	2-cyano	A-152	Mass spectrum (m/z): 391(M+1), 413(M+23)
A-161	4-cyano	A-152	Mass spectrum (m/z): 391(M+1), 413(M+23)

By using a method similar to the general example A-152, the following compounds can be synthesized as set forth in Table A-2:

10

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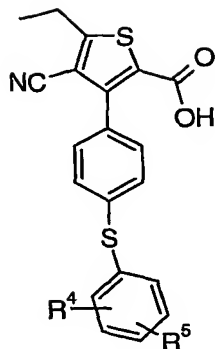


Table A-3

No.	R <sup>4</sup>	R <sup>5</sup>	Data
A-162	5-F	2-CN	Mass Spectrum (m/z) 431(M+23)
A-163	4-F	2-CN	Mass Spectrum (m/z) 431(M+23)

By using a method similar to the general example A-152 and A-152A, the  
 5 following compounds can be synthesized as set forth in Table A-2:

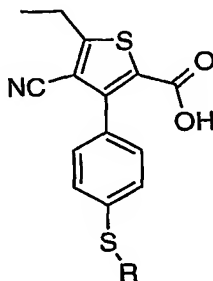
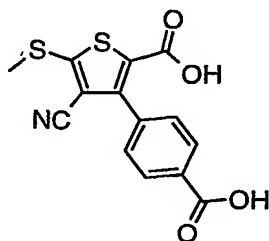
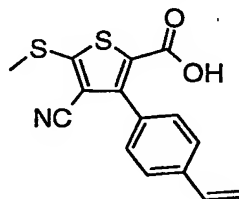


Table A-4

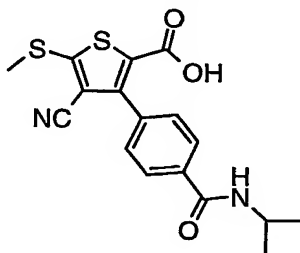
No	R	Method	Data
A-164	<i>n</i> -propyl	A-152 A	Mass spectrum (m/z): 332(M+1), 354(M+23)
A-165	cyclopentyl	A-152 A	Mass spectrum (m/z): 356(M-1), 312 (M-45)
A-166	2-(4-pyridyl)ethyl	A-152 A	
A-166A	2-(2-pyridyl)ethyl	A-152 A	Mass spectrum (m/z): 395 (M+1)
A-167	4-pyridyl	A-152	Mass spectrum (m/z): 367(M+1)

Example A-1713-(4-Carboxy-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid

5 Prepare the title compound in a manner analogous to the procedure set forth in example A-2 using 4-cyano-3-(4-methoxycarbonyl-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid ethyl ester as starting material: MS (ES<sup>+</sup>, m/e): 320 (M+1).

Example A-1724-Cyano-5-methylsulfanyl-3-(4-vinyl-phenyl)-thiophene-2-carboxylic acid

10 Prepare the title compound in a manner analogous to the procedure set forth in example A-2 using 4-Cyano-5-methylsulfanyl-3-(4-vinyl-phenyl)-thiophene-2-carboxylic acid ethyl ester as starting material: MS (ES<sup>+</sup>, m/e): 302 (M+1).

Example A-1734-Cyano-3-(4-isopropylcarbamoyl-phenyl)-5-methylsulfanyl-thiophene-2-carboxylic acid

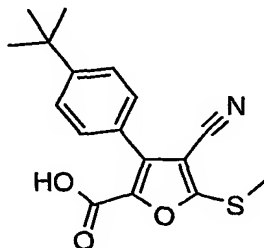
15 Combine 3-(4-Carboxy-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid (0.1 g, 1.0 eq) in CH<sub>2</sub>Cl<sub>2</sub> (5.0 mL) and stir. Add carbonyldiimidazole (2.0 eq). Stir  
20 the mixture overnight. Add isopropylamine (1.0 eq) and stir overnight at room



temperature. Add 1N HCl water solution. Filter the precipitate to provide the title compound (0.03 g, Yield 27%). MS (ES+, m/e): 361 (M+1).

Example A-174

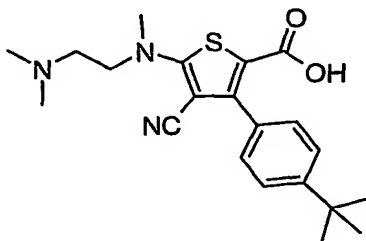
3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-furan-2-carboxylic acid



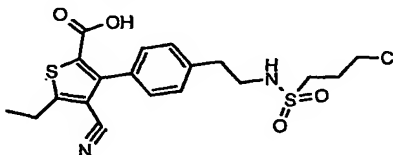
Dissolve 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-furan-2-carboxylic acid ethyl ester (110 mg, 0.32 mmol) in a solution of THF: MeOH: H<sub>2</sub>O (3:2:1, 5 ml). Add lithium hydroxide (80 mg, 3.3 mmol) to the mixture and stir the reaction at 60 °C for 30 minutes. Add 6N HCl until pH approx. 1 to obtain the desired white solid of the titled compound (30 mg, 30%): Mass spectrum (M-1) = 314. EA, Calculated: C; 61.91, H; 5.68, N; 4.25. Found: C; 61.75, H; 5.42, N; 3.91.

Example A-175

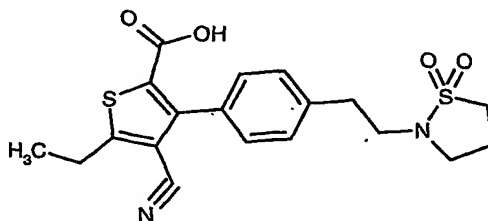
3-(4-tert-Butyl-phenyl)-4-cyano-5-[(2-dimethylamino-ethyl)-methyl-amino]-thiophene-2-carboxylic acid



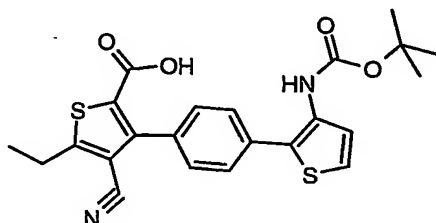
Prepare the title compound in a manner analogous to the procedure set forth in example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-[(2-dimethylamino-ethyl)-methyl-amino]-thiophene-2-carboxylic acid ethyl ester to provide the title compound: Mass spectrum (m/e): 386 (M+1). <sup>1</sup>H NMR (DMSO, 200 MHz): δ 7.4 (d, 2H, J= 8.2 Hz); 7.25 (d, 2H, J= 8.2 Hz); 3.70 (m, 2H); 3.2 (s, 3H); 2.55 (m, 2H); 2.2 (s, 6H); 1.3 (s, 9H).

Example A-1763-{4-[2-(3-Chloropropane-1-sulfonylamino)-ethyl]-phenyl}-4-cyano-5-ethyl-thiophene-2-carboxylic acid

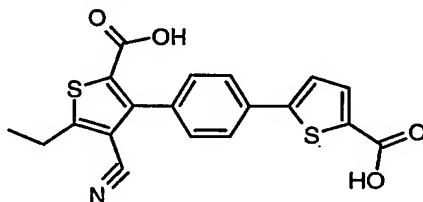
5 Add dioxane (1.0 mL) to 3-{4-[2-(3-chloropropane-1-sulfonylamino)-ethyl]-phenyl}-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (0.078 g, 0.16 mmol) and then 2.5 M aqueous solution of LiOH (1.0 mL) and stir at 15 min 40°C. Cool down, evaporate dioxane under reduce pressure and add 3M HCl and filter. Purify by reverse phase HPLC (0.05% TFA pH 2.5, using acetonitrile as organic solvent) to give 0.022 g of the title compound as a white semisolid. Mass spectrum ESI positive (m/z): 441 (M+1), 458 (M+18), 463 (M+23).

Example A-1774-Cyano-3-{4-[2-(1,1-dioxo-1λ6-isothiazolidin-2-yl)-ethyl]phenyl}-5-ethyl-3-(4-[1,2,4]-thiadiazol-2-yl-phenyl)-thiophene-2-carboxylic acid

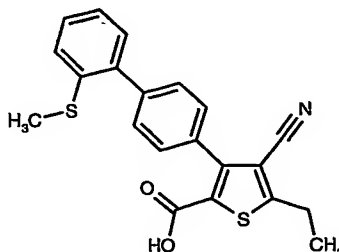
15 Prepare the title compound in a manner analogous to the procedure set forth in preparation of Example A-176, heating at 60°C for 15 min, starting from 4-cyano-3-{4-[2-(1,1-dioxo-1λ6-isothiazolidin-2-yl)-ethyl]phenyl}-5-ethyl-3-(4-[1,2,4]-thiadiazol-2-yl-phenyl)-thiophene-2-carboxylic acid ethyl ester. Purify by HLB (C18) cartridges to give 0.103 g of the title compound as a white solid. Mass spectrum ESI positive (m/z): 405 (M+1), 422 (M+18), 427 (M+23).

Example A-1783-[4-(3-*tert*-Butoxycarbonyl-thiophen-2-yl)phenyl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid

5 Stir 3-[4-(3-*tert*-butoxycarbonylamino-thiophen-2-yl)phenyl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester (0.17 g, 0.36 mmol) in a mixture of ethanol (4 mL) and 2.5 M LiOH aqueous solution (1 mL) at 60°C for 1h. Add ethyl acetate and separate phases. Acidify organic phase with acetic acid, dry (sodium sulfate) and concentrate in vacuo. Recrystallize the solid from ethyl acetate to give 0.042 g of the title  
10 compound as a white solid. Mass spectrum ESI positive (m/z): 477 (M+23).

Example A-1793-[4-(5-Carboxy-thiophen-2-yl-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid

15 Add 2.5 M aqueous solution of LiOH (0.5 mL) to a suspension of material from 3-[4-(5-carboxy-thiophen-2-yl-phenyl)-4-cyano-5-ethyl thiophene-2-carboxylic acid ethyl ester (0.027 g, 0.06 mmol) in ethanol (1.5 mL) and stir at 60°C for 20 min. Evaporate ethanol, add 1.2M HCl and filter. Purify the solid through a silica gel cartridge eluting with ethyl acetate first and then ethyl acetate-TFA(20:1) to give 0.02 g of the title  
20 compound. Mass spectrum ESI positive (m/z):384 (M+1), 401 (M+18).

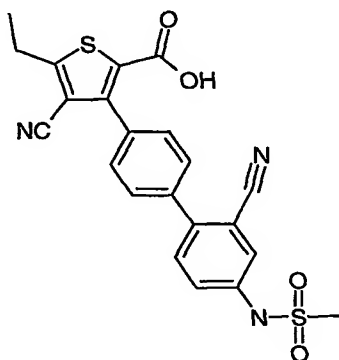
Example A-1804-Cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester

- 5           Add acetone, (1.87L) and 4-cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester (144.1 g, 0.353 mol) to a 5L reaction flask equipped with an overhead stirrer, condenser, nitrogen inlet, thermocouple, addition funnel, and heating mantle. Heat the mixture to 55° C and add methanol (0.29 L). Add 2.0 N sodium hydroxide (221 mL, 0.442 mol) via an addition funnel. Observe substantial
- 10   depletion of 4-cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid ethyl ester and 4-cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid methyl ester. Add deionized water (925 mL) and warm the resulting mixture to 67° C. Add 1.0 N hydrochloric acid (0.442 L, 1.25 eq) over 5 minutes and slowly cool the mixture to 23° C over 4 hours. Collect the precipitate by filtration and
- 15   rinse with aqueous acetone (1:1 acetone: water, three rinses of 60 ml each). This affords 219 g of wet cake. Add the wet cake, 115.6 g dry of 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid prepared in similar fashion, and acetone (1.5 L) to a 4 L beaker and stir at room temperature until a turbid solution is observed. Clarify the solution by filtration through Celite® and rinse with acetone (200 mL).
- 20           Transfer the filtrate to a 5L reaction flask equipped with heating mantle, overhead stirrer, condenser, nitrogen inlet, thermocouple, and addition funnel. Warm the solution to reflux. Add deionized water (1.45 L) while heating to 65° C. Stir and heat the resulting suspension at 65° C for 1 hour, and cool the solution to 50° C. Stir at 50° C for 9 hours. Slowly reduce the temperature from 50° C to 24° C over 6 hours and filter to
- 25   collect the precipitate. Rinse the filter cake with aqueous acetone (1:1 acetone: water, two rinses of 150 ml each). Vacuum dry the solids at 50° C to a constant weight to afford the title compound (229 grams, 89.8 % yield). HPLC =99.4% (mobile phase = 27% 0.1%

TFA in water, 73% ACN, 1.5 ml/min isocratic; Column = Zorbax SB-Phenyl 5um 4.6mm x 25cm at 35C; UV detection at 210 nm).

Example A-181

5     4-Cyano-3-(2'-cyano-4'-methanesulfonylamino-biphenyl-4-yl)-5-ethyl-thiophene-2-carboxylic acid

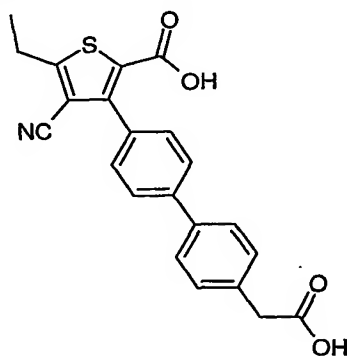


10     Prepare the title compound in a manner analogous to the procedure set forth in General example A-8, using 4-Cyano-3-(2'-cyano-4'-methanesulfonylamino-biphenyl-4-yl)-5-ethyl-thiophene-2-carboxylic acid ethyl ester as starting material and then hydrolyzing the compound in a manner analogous to the procedure set forth in Example A-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid. Mass spectrum (m/e): 452 ( $M^+ + 1$ ).

15

Example A-184

3-(4'-Carboxymethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid



Prepare the title compound in a manner analogous to the procedure set forth in the example A-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic

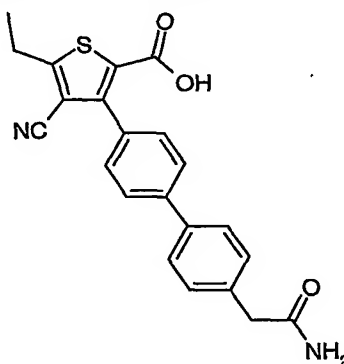
acid, to provide the title compound plus 3-(4'-carbamoylmethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid (Example A-185) in ratio 6:4. Purification by HPLC.

Mass spectrum (m/e): 392 ( $M^+ + 1$ ).

5

Example A-185

3-(4'-Carbamoylmethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid



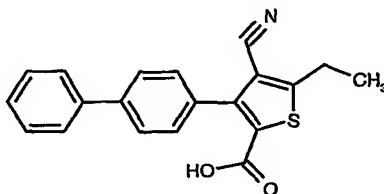
Prepare the title compound in a manner analogous to the procedure set forth in the example A-2, 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid, to provide the title compound plus 3-(4'-carbamoxymethyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid (Example A-184). Purification by HPLC. Mass spectrum (m/e): 391 ( $M^+ + 1$ ).

10

Example A-186

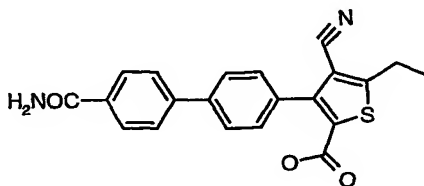
3-Biphenyl-4-yl-4-cyano-5-ethyl-thiophene-2-carboxylic acid

15

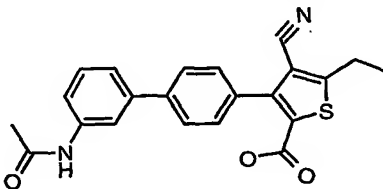


Prepare the title compound in a manner analogous to the procedure set forth in Example A-151 using compound from Example 150 (0.100 g), phenyl boronic acid (0.044 g) and Pd black (0.003 g) in ethanol-water at 85°C. Purify by reverse phase SPE cartridge and HPLC to give 0.03 g of the desired compound as a white solid. Mass spectrum ESI positive (m/z): 334 ( $M + 1$ ).

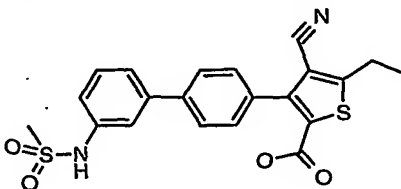
20

Example A-1873-(4'-Carbamoyl-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid

5 Prepare the title compound in a manner analogous to the procedure set forth in Example A-186 using compound from Example 150 (0.050 g) and 4-aminocarbonylphenyl boronic acid (0.026 g) in 2-propanol-water. Purify by chromatography using silica gel and hexanes (0.05% TFA)-ethyl acetate gradient to give 0.035 g of the desired compound as a white solid. Mass spectrum ESI negative (m/z): 375 (M-1).

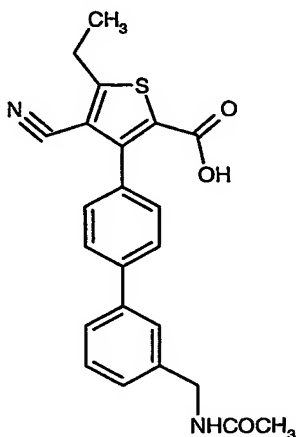
Example A-1883-(3'-Acetylamino-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid

15 Prepare the title compound in a manner analogous to the procedure set forth in Example A-187 using compound from Example 150 (0.100 g), 3-acetylamino-phenyl boronic acid (0.064 g) and dichlorobis(acetonitrile)palladium (II) (0.008 g). Purify by chromatography using silica gel and dichloromethane-MeOH gradient, followed by recrystallization from acetone-hexanes to give 0.034 g of the desired compound as a white solid. Mass spectrum ESI positive (m/z): 391 (M+1).

Example A-1894-Cyano-5-ethyl-3-(3'-methanesulfonylamino-biphenyl-4-yl)-thiophene-2-carboxylic acid

Prepare and purify the title compound in a manner analogous to the procedure set forth in Example A-188 using compound from Example 150 (0.100 g) and 3-methanesulfonylamino-phenyl boronic acid (0.077 g), to give 0.056 g of the desired compound as a white solid. Mass spectrum ESI positive (m/z): 427 (M+1).

5

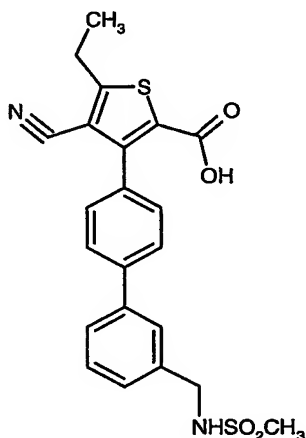
Example A-1903-[3'-(Acetylamino-methyl)-biphenyl-4-yl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid

Prepare the title compound in a manner analogous to the procedure set forth in Example A-179, using 3-[3'-(acetylamino-methyl)-biphenyl-4-yl]-4-cyano-5-ethyl-thiophene-2-carboxylic acid ethyl ester. Work-up includes acidify, filter the solid and wash it with hexanes, to give the desired compound.

10

Example A-1914-Cyano-5-ethyl-3-[3'-(methanesulfonylamino-methyl)-biphenyl-4-yl]-thiophene-2-carboxylic acid

15



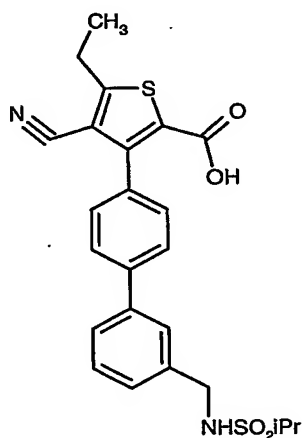


Prepare the title compound in a manner analogous to the procedure set forth in Example A-179, using 4-cyano-5-ethyl-3-[3'-(methanesulfonylamino-methyl)-biphenyl-4-yl]-thiophene-2-carboxylic acid ethyl ester. Work-up includes acidify, filter the solid and wash it with hexanes, to give the desired compound.

5

Example A-192

4-Cyano-5-ethyl-3-[3'-(propane-2-sulfonylamino-methyl)-biphenyl-4-yl]-thiophene-2-carboxylic acid



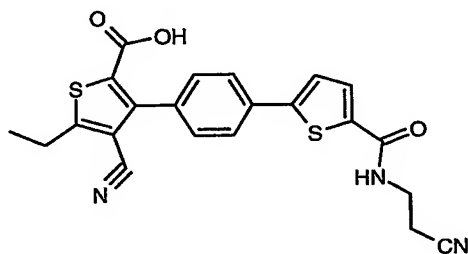
10

Prepare the title compound in a manner analogous to the procedure set forth in Example A-179, using 4-cyano-5-ethyl-3-[3'-(propane-2-sulfonylamino-methyl)-biphenyl-4-yl]-thiophene-2-carboxylic acid ethyl ester. Extract the acidic aqueous phase with ethyl acetate and the organic phase dry and concentrate *in vacuo*. Wash the residue with a mixture of diethyl ether-ethyl acetate-hexanes to give the desired compound.

15

Example A-193

4-Cyano-3-{4-[5-(2-cyano-ethylcarbamoyl)-thiophen-2-yl]-phenyl}-5-ethyl thiophene-2-carboxylic acid

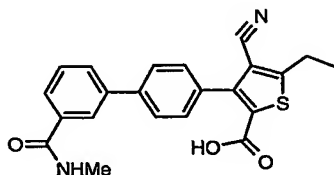


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Prepare the title compound in a manner analogous to the procedure set forth in Example A-179, using 4-cyano-3-{4-[5-(2-cyano-ethylcarbamoyl)-thiophen-2-yl]-phenyl}-5-ethyl thiophene-2-carboxylic acid ethyl ester, at 45°C. After work-up as in Example A-179, the residue was purified by HPLC to give 0.004 g of the desired compound. Mass spectrum ESI negative (m/z): 434 (M-1).

#### Example A-193A

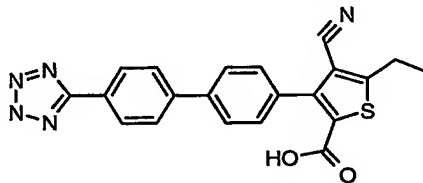
##### 4-Cyano-5-ethyl-3-(3'-methylcarbamoyl-biphenyl-4-yl)-thiophene-2-carboxylic acid



Prepare the title compound in a manner analogous to the procedure set forth in Example A-179, using material from 4-cyano-5-ethyl-3-(3'-methylcarbamoyl-biphenyl-4-yl)-thiophene-2-carboxylic acid. Add ethyl acetate to the crude reaction mixture and extract thoroughly. Wash combined organic layers with 1M aqueous HCl, dry (anhydrous sodium sulfate) and purify using silica gel Strata® cartridges eluting with dichloromethane-MeOH gradient, to give 0.006 g of the desired product. Mass spectrum ESI negative (m/z): 389 (M-1).

#### Example A-194

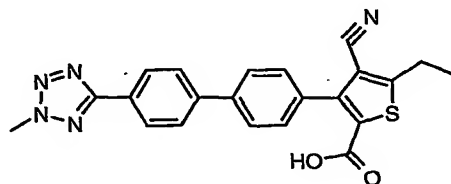
##### 4-Cyano-5-ethyl-3-[4'-(1(2)H-tetrazol-5-yl)-biphenyl-4-yl]-thiophene-2-carboxylic acid



Prepare the title compound in a manner analogous to the procedure set forth in Example A-179, using 4-cyano-5-ethyl-3-[4'-(1(2)H-tetrazol-5-yl)-biphenyl-4-yl]-thiophene-2-carboxylic acid ethyl ester. Wash the solid with water and hexane and dry it, to give 0.006 g of the title compound. Mass spectrum ESI positive (m/z): 402 (M+1).

Example A-195

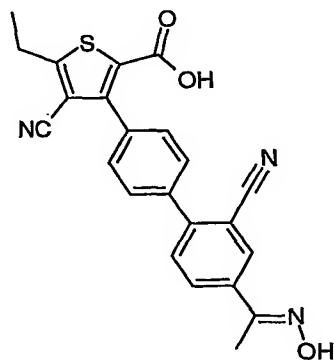
4-Cyano-5-ethyl-3-[4'-(2-methyl-2H-tetrazol-5-yl)-biphenyl-4-yl]-thiophene-2-carboxylic acid



- 5 Prepare the title compound in a manner analogous to the procedure set forth in Example A-179, using 4-cyano-5-ethyl-3-[4'-(2-methyl-2H-tetrazol-5-yl)-thiophene-2-carboxylic acid ethyl ester. Add 1.2 M aqueous HCl and extract thoroughly with ethyl acetate. Wash combined organic phases with brine, dry (anhydrous sodium sulfate) and concentrate *in vacuo*. Purify by HPLC to give the title compound as a white solid (0.0027g). Mass spectrum ESI positive ( $m/z$ ): 416 ( $M+1$ ).
- 10

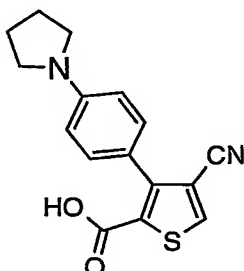
Example A-196

4-Cyano-3-[2'-cyano-4'-(1-hydroxyimino-ethyl)-biphenyl-4-yl]-5-ethyl-thiophene-2-carboxylic acid

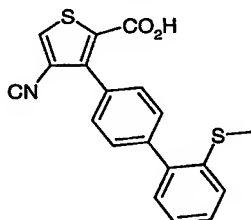


- 15 Add a solution of hydroxylamine in EtOH (0.5 ml) (from the mixture of hydroxylamine hydrochloride (0.055 mmol) and triethylamine (0.055 mmol) at RT) over 3-(4'-Acetyl-2'-cyano-biphenyl-4-yl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid (Example A-143) in EtOH (0.5 ml) and heat at 50°C for 1 hour. Cool the mixture to RT (white solid crash out) and remove the solvents under reduced pressure. Suspend the solid resultant in water and filter the solid under vacuum. Mass spectrum ( $m/e$ ): 416 ( $M^++1$ ).
- 20

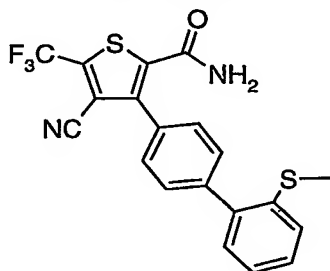
-200-

Example A-1974-Cyano-3-(4-pyrrolidin-1-yl-phenyl)-thiophene-2-carboxylic acid

Prepare the title compound in a manner analogous to the procedure set forth in  
5 example A-2, 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic  
acid using 3-(4-pyrrolidin-1-yl-phenyl)-4-cyano-5-methanesulfonyl-thiophene-2-  
carboxylic acid ethyl ester as starting material. Mass spectrum (m/e): 299 (M+1).

Example A-1984-Cyano-3-2-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid

Prepare the title compound in a manner similar to the one described in Example  
A-146 using THF as the solvent and stirring for 2 h at 60°C, to give 0.08 g. Mass  
spectrum ESI (m/z) 374 (M+23).

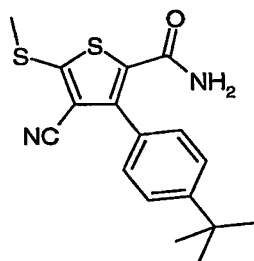
Example AM-14-Cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic  
acid amide

Prepare substantially in accordance with the method of general procedure 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid amide starting with the title compound 4-cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic acid: MS found (M-1) 417.

5

#### Example AM-2

##### 3-(4-tert-Butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid amide

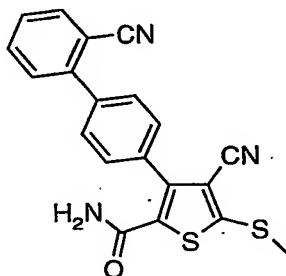


Combine 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid (0.272 mmol) in 3 ml CH<sub>2</sub>Cl<sub>2</sub> in a 25 ml round bottom. Add oxalyl chloride (0.33 mmol) followed by (0.06 mmol) of DMF. Stir mixture stir for 1 hr. at RT and concentrate on rotovap to dryness. Dissolve resultant residue in 3 ml CH<sub>2</sub>Cl<sub>2</sub> and add (2.8mmol) of conc. NH<sub>4</sub>OH. A solid immediately precipitates. Concentrate reaction to dryness and chromatograph on 1000 micron (Si) radial chromatography plate eluting with 5%MeOH / CH<sub>2</sub>Cl<sub>2</sub>. Concentrate the desired fractions to provide the desired title compound: MS found (M+1) 331.4.

15

#### Example AM-3

##### 4-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-methylsulfanyl-thiophene-2-carboxylic acid amide



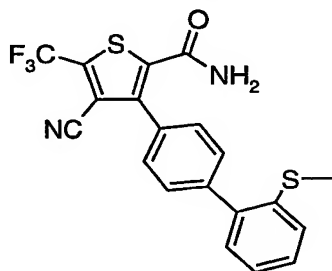
20

Prepare a solution of 4-cyano-3-(2'-cyano-biphenyl-4-yl)-5-methylsulfanyl-thiophene-2-carboxylic acid (250mg, 0.66 mmol) in 5mL of CH<sub>2</sub>Cl<sub>2</sub> and stir under

-202-

nitrogen. Add 2 drops of dry DMF and cool the mixture to 0°C. Next add oxalyl chloride (0.1mL, 1.15 mmol) dropwise over five minutes. Remove the ice-bath and stir the reaction one hour. Add another 0.1mL of oxalyl chloride and continue stirring for another hour. Concentrate the reaction mixture to a yellow solid. Dissolve the crude acid  
5 chloride in 5mL of THF, cool to 0°C and add 2mL of concentrated NH<sub>4</sub>OH. After stirring for 1 hour dilute the reaction with 20mL of ice-water and filter off the solid, rinsing well with water. Vacuum-dry overnight to give the title compound, 175mg (70%) as an off-white solid. MS (ES-, m/e) = 374 (M<sup>+</sup>-1); HPLC = 97%.

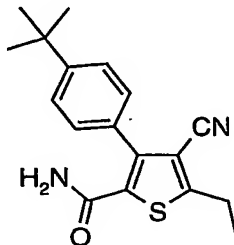
10

Example AM-44-Cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic acid amide

Prepare substantially in accordance with the procedure of 3-(4-tert-butyl-phenyl)-  
15 4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid amide starting with the title compound 4-cyano-3-(2'-methylsulfanyl-biphenyl-4-yl)-5-trifluoromethyl-thiophene-2-carboxylic acid: MS found (M-1) 417.

Example AM-5

20

3-(4-tert-Butyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid amide

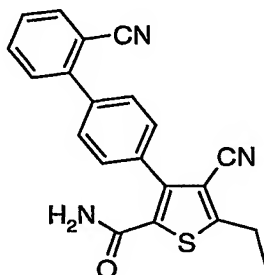
Prepare the title compound in a manner analogous to the procedure set forth in Example AM-3 using 3-(4-tert-Butyl-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic

-203-

acid (300 mg, 0.96 mmol) to give the title compound as a white solid. Yield = 284 mg (95%). MS (ES<sup>+</sup>, m/e) = 313 (M<sup>+</sup>+1); HPLC = 98%.

Example AM-6

5     4-Cyano-3-(2'-cyano-biphenyl-4-yl)-5-ethyl-thiophene-2-carboxylic acid amide

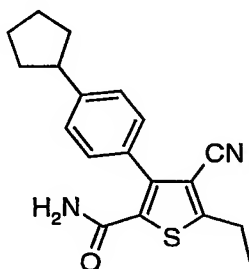


Prepare the title compound in a manner analogous to the procedure set forth in Example AM-3 using 4-cyano-3-(2'-cyano-biphenyl-4-yl)-5-ethyl-thiophene-2-carboxylic acid (300 mg, 0.84 mmol). Yield = 241 mg (81%). MS(ES<sup>+</sup>, m/e) = 358 (M<sup>+</sup>+1); HPLC = 94%.

10

Example AM-7

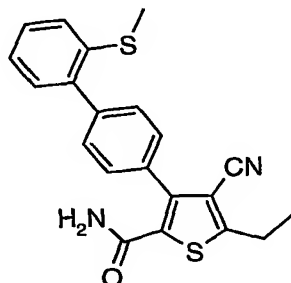
4-Cyano-3-(4-cyclopentyl-phenyl)-5-ethyl-thiophene-2-carboxylic acid amide



Prepare the title compound in a manner analogous to the procedure set forth in Example AM-3 using 4-cyano-3-(4-cyclopentyl-phenyl)-5-ethyl-thiophene-2-carboxylic acid (250 mg, 0.77 mmol). Yield = 243 mg (97%). MS(ES<sup>+</sup>, m/e) = 325 (M<sup>+</sup>+1); HPLC = 98%.

15

20

Example AM-84-Cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid amide

Prepare the title compound in a manner analogous to the procedure set forth in

- 5 Example AM-3 using 4-cyano-5-ethyl-3-(2'-methylsulfanyl-biphenyl-4-yl)-thiophene-2-carboxylic acid (174 mg, 0.46 mmol). Yield = 139 mg (80%). MS(ES<sup>-</sup>, m/e) = 377 (M<sup>+</sup>-1); HPLC = 95%.

Prepare the following amides as set forth in Table AM-1 in a manner analogous to the

- 10 procedure set forth in Example AM-2:

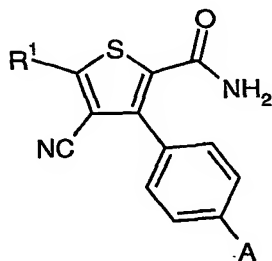
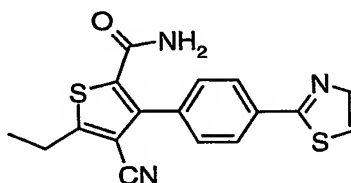


Table AM-1

No.:	R <sup>1</sup>	A	Data
AM-9	MeS	2-cyanophenyl	mass spectrum (m/e): 374 (M+1).
AM-10	Ethyl	Thiophen-2-yl	mass spectrum (m/e): 339 (M+1).
AM-12	Ethyl	3-cyanopyridine-2-yl	mass spectrum (m/e): 359 (M+1).
AM-14	Ethyl	3-methylthio-thiophen-2-yl	mass spectrum (m/e): 383 (M-1).
AM-15	Ethyl	3-cyano-thiophen-2-yl	mass spectrum (m/e): 364 (M+1).



Example AM-164-Cyano-5-ethyl-3-(4-thiazol-2-yl-phenyl)-thiophene-2-carboxamide

Add oxalyl chloride (0.050 mL, 0.57 mmol) to a suspension of 4-cyano-5-ethyl-3-(4-thiazol-2-yl-phenyl)-thiophene-2-carboxylic acid (0.15 g, 0.44 mmol) and DMF (0.1 mL) in dichloromethane at 0°C. Stir 1h at 23°C and add 1M solution of ammonia in dioxane (5 mL). Concentrate in vacuo, suspend the solid in ethyl acetate and filter to give 0.052 g of the title compound as a white solid. Mass spectrum ESI positive (m/z): 340 (M+1), 362 (M+23).

Prepare the following amides as set forth in Table AM-2 in a manner analogous to the procedure set forth in general preparation 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid amide:

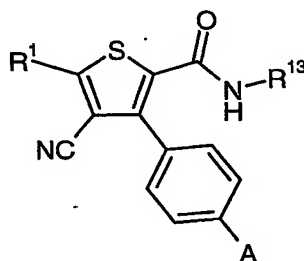
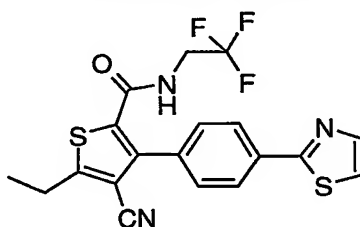


Table AM-2

No.:	R <sup>1</sup>	A	R <sup>13</sup>	Data
AM-30	Ethyl	Tert-butyl	1H-Tetrazol-5-yl	mass spectrum (m/e): 381 (M+1).
AM-31	Ethyl	Tert-butyl	[1,3,4]Thiadiazol-2-yl	mass spectrum (m/e): 395 (M+1).
AM-32	Ethyl	Tert-butyl	[1,2,4]Triazol-3-yl	mass spectrum (m/e): 378 (M-1).
AM-33	Ethyl	2-cyanophenyl	1H-Tetrazol-5-yl	mass spectrum (m/e): 426 (M+1).
AM-34	Ethyl	Cyclopentyl	1H-Tetrazol-5-yl	mass spectrum (m/e): 393 (M+1).
AM-35	MeS	t-Butyl	isopropyl	H-NMR (DMSO-d <sub>6</sub> ) δ: 0.865 (d, 6H, J=6.4 Hz); 1.30 (s, 9H); 2.75 (s, 3H); 3.8 (m, 1H);

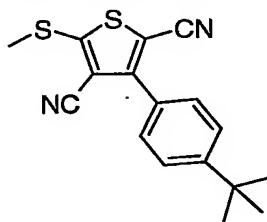
No.:	R <sup>1</sup>	A	R <sup>13</sup>	Data
				6.9 (br d, 1H); 7.35 (m, 2H); 7.52 (m, 2H)
AM-36	MeS	t-Butyl	CH <sub>3</sub>	H-NMR (DMSO-d <sub>6</sub> ) d: 1.30 (s, 9H); 2.58 (d, 3H, J=4.3 Hz); 2.74 (s, 3H); 7.34 (m, 2H); 7.49 (m, 2H); 7.66 (m, 1H)

Example AM-374-Cyano-5-ethyl-3-(4-thiazol-2-yl-phenyl)-thiophene-2-carboxylic acid (2,2,2-trifluoroethyl) amide

5

Prepare the title compound in a manner analogous to the procedure set forth in preparation of Example AM-16 using 2,2,2-(trifluoroethyl)amine (2 equiv). Wash the reaction mixture with water, 0.5M aqueous NaOH solution (x3), dry organic layer over sodium sulfate and evaporate. Wash the solid with diethyl ether-hexanes to give 0.015 g of the title compound as a white solid. Mass spectrum ESI positive (m/z): 422 (M+1), 444 (M+23).

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Example C-13-(4-tert-Butyl-phenyl)-5-methylsulfanyl-thiophene-2,4-dicarbonitrile

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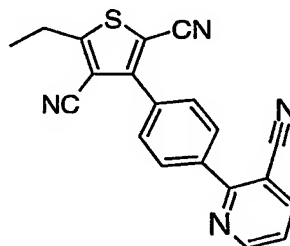
Add 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-carboxylic acid amide (0.121 mmol) to 0.5 ml of CH<sub>3</sub>CN and add 18 mg paraformaldehyde and formic acid (1.59 mmol). Heat for 6 hrs. Concentrate and purify by radial

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chromatography eluting with ethyl acetate / hexanes to provide the title compound.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.39 (q, 4H,  $J = 12.0$  Hz), 2.80 (s, 3H) and 1.42 (s, 9H).

### Example C-2

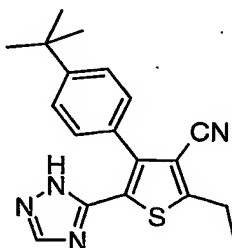
#### 5 3-[4-(3-Cyano-pyridin-2-yl)-phenyl]-5-ethyl-thiophene-2,4-dicarbonitrile



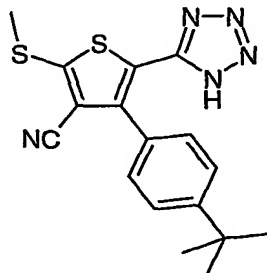
Prepare the title compound in a manner analogous to the procedure set forth in Example AM-3 using 4-cyano-5-ethyl-3-[4-(3-cyano-pyridin-2-yl)-phenyl]-thiophene-2-carboxylic acid (Example A-127). Yield = (10%). MS(ES+,  $m/e$ ) = 341 ( $M^+ + 1$ ). plus 18% of 4-cyano-3-[4-(3-cyano-pyridin-2-yl)-phenyl]-5-ethyl-thiophene-2-carboxylic acid amide (example AM-12).

### Example T-1

#### 4-(4-tert-Butyl-phenyl)-2-ethyl-5-(2H-[1,2,4]triazol-3-yl)-thiophene-3-carbonitrile



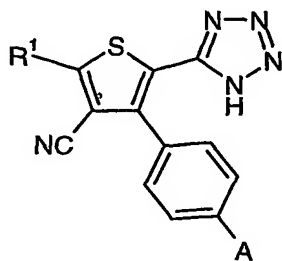
15 Dissolve 3-(4-tert-butyl-phenyl)-4-cyano-5-ethyl-thiophene-2-carboxylic acid dimethylaminomethyleneamide (261 mg, 0.71 mmol) in 2 mL of glacial acetic acid, add hydrazine monohydrate (50  $\mu\text{L}$ , 1.03 mmol) and heat to  $90^\circ\text{C}$  under nitrogen. After 90 minutes cool the reaction slightly, pour into 50 mL of ice-water and stir for twenty  
20 minutes. Filter off the resulting solid and rinse with 10 mL of water. Vacuum-dry overnight to give the title compound, 206 mg (86%). MS(ES+,  $m/e$ ) = 337 ( $M^+ + 1$ ); HPLC = 100%.

Example T-24-(4-tert-Butyl-phenyl)-2-methylsulfanyl-5-(1H-tetrazol-5-yl)-thiophene-3-carbonitrile

Combine 3-(4-tert-butyl-phenyl)-4-cyano-5-methylsulfanyl-thiophene-2-

- 5 carboxylic acid amide (0.142 mmol) and 1.5 ml CH<sub>3</sub>CN with NaN<sub>3</sub> (0.43mmol) and SiCl<sub>4</sub> (0.142 mmol) in CH<sub>2</sub>Cl<sub>2</sub> and reflux the mixture for 16 hrs. MS shows desired product and starting material. Conc. to dryness and purification by radial chromatography (Si) on a 1000 micron plate eluting with 5% MeOH / 0.5% AcOH / CH<sub>2</sub>Cl<sub>2</sub>. Concentrate desired fractions to provide the desired title compound: <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)
- 10 δ 7.40 (q, 4H, J= 22 Hz), 2.73 (s, 3H), and 1.35 (s, 9H), MS found (M+1) 356.2.

Prepare the following tetrazoles as set for Table T-1 in a manner analogous to the procedure set forth in Example 4-(4-tert-butyl-phenyl)-2-methylsulfanyl-5-(1H-tetrazol-5-yl)-thiophene-3-carbonitrile.



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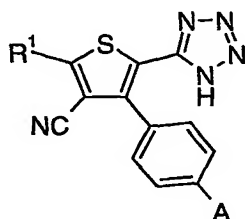
Table T-1

No.:	R <sup>1</sup>	A	Data
T-3	MeS	Tert-butyl	mass spectrum (m/e): 356 (M+1).
T-4	Ethyl	2-fluorophenyl	mass spectrum (m/e): 376 (M+1).
T-5	MeS	2-cyanophenyl	mass spectrum (m/e): 399 (M-1).
T-6	Ethyl	2-cyanophenyl	mass spectrum (m/e): 383 (M+1).
T-7	Ethyl	2-methylthiophenyl	mass spectrum (m/e): 404 (M+1).

No.:	R <sup>1</sup>	A	Data
T-8	Ethyl	Tert-butyl	mass spectrum (m/e): 336 (M-1).
T-9	Ethyl	Cyclopentyl	mass spectrum (m/e): 350 (M+1).
T-10	Ethyl	Thiophen-2-yl	mass spectrum (m/e): 364 (M+1).
T-11	Ethyl	3-cyanopyridine-2-yl	mass spectrum (m/e): 384 (M+1).
T-12	Ethyl	3-chlorothiophen-2-yl	mass spectrum (m/e): 396 (M-1).

### General Example T-13

#### 2-R<sup>1</sup>-5-(1(2)*H*-tetrazol-5-yl)-4-(4-A-phenyl)-thiophene-3-carbonitrile



R= Me, Et

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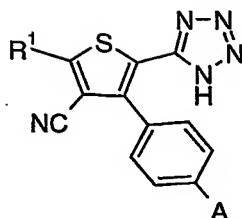
Combine 4-Iodo-2-R<sup>1</sup>-5-(1H-tetrazol-5-yl)-thiophene-3-carbonitrile (preparation 53 and 56) (1.0 mmol), the corresponding phenyl boronate (1.0-1.1 mmol), tetrakis(triphenylphosphine)palladium (0) (0.05 mmol), and 2M sodium carbonate (4 mmol) solution in DME (10 ml) and heat to reflux. After 18-24 hours cool to room temperature and add water. Extract with ethyl acetate. Combine the organics and wash with water and brine, dry over sodium sulfate, filter and concentrate under reduced pressure. Purify by flash chromatography eluting with dichloromethane:MeOH to provide the title compound.

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Prepare the following tetrazoles as set for Table T-2 in a manner analogous to the procedure set forth in General Example T-13, 2-R<sup>1</sup>-5-(1(2)*H*-tetrazol-5-yl)-4-(4-A-phenyl)-thiophene-3-carbonitrile.

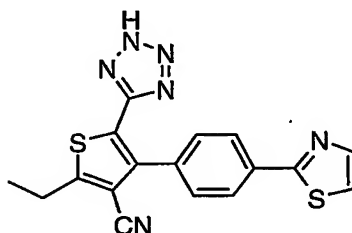
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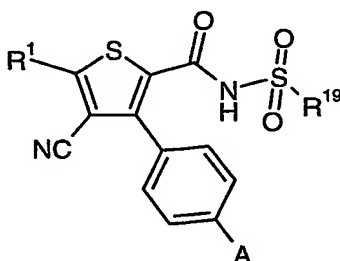
R= Me, Et

Table T-2.

Ex No.	R <sup>1</sup>	A	Data
T-14	Methyl	3-methylthio-thiophene-2-yl	mass spectrum (m/e): 396 (M+1).
T-15	Ethyl	4-Cyano-5-ethyl-thiophene-2-(1H-tetrazol-5-yl)-3-yl	mass spectrum (m/e): 485 (M+1).
T-16	Ethyl	3-thiomethylthiophen-2-yl	mass spectrum (m/e): 408 (M-1).
T-18	Ethyl	3-cyanothiophen-2-yl	mass spectrum (m/e): 389 (M+1).

Example T-195     2-Ethyl-5-(1(2)H-tetrazole-5-yl)-4-(4-thiazol-2-yl-phenyl)-thiophene-3-carbonitrile

Add silicon tetrachloride (1M in dichloromethane, 0.59 mmol) to a suspension of sodium azide (0.116 g, 1.76 mmol) in dry acetonitrile (2 mL) and warm 5 min at 95°C. Add 4-cyano-5-ethyl-3-(4-thiazol-2-yl-phenyl)-thiophene-2-carboxamide (0.05 mg, 0.147 mmol, mixed with 1 equiv of silicon tetrachloride and 3 equiv of sodium azide) in acetonitrile and stir under reflux for 16h. Add ethyl acetate and water and separate phases. Wash organic layer with water (x2) and back-extract aqueous layer with ethyl acetate (x2). Wash organic layers with brine, dry (sodium sulfate) and concentrate. Purify by reverse phase SPE cartridges to give 0.041 g of the title compound as a white solid. Mass spectrum ESI positive (m/z): 365 (M+1), 387 (M+23).

General Example S-1R<sup>19</sup>-Sulfonic acid-[4-cyano-3-(4-A-phenyl)-5-R<sup>1</sup>-thiophene-2-carbonyl]-amide

Dissolve the carboxylic acid (0.20 mmol) in 3mL of CH<sub>2</sub>Cl<sub>2</sub> and add Alkyl-sulfonamide (0.25 mmol), DMAP (0.23 mmol) and (3-dimethylamino-propyl)-ethyl-carbodiimide hydrochloride (0.25 mmol). Stir the resulting mixture under nitrogen at room temperature for 18 hours. Dilute with 20 mL of CH<sub>2</sub>Cl<sub>2</sub> and wash with 1N HCl (1 x 5 mL), dry over Na<sub>2</sub>SO<sub>4</sub>, filter and evaporate. Chromatograph on silica gel in 1/9 MeOH/CH<sub>2</sub>Cl<sub>2</sub> to give the title compound.

Prepare the following acyl sulfonamides as set forth in Table S-1 in a manner analogous to the procedure set forth in general example S-1:

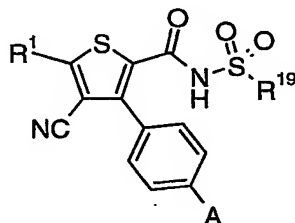


Table S-1

No.:	R <sup>1</sup>	A	R <sup>19</sup>	Data
S-2	MeS	t-Butyl	Methyl	Mass spectrum (m/e): 407 (M-1)
S-3	MeS	t-Butyl	i-Propyl	Mass spectrum (m/e): 437 (M+1)
S-4	MeS	1-pyrrolidine	i-Propyl	Mass spectrum (m/e): 450 (M+1)
S-5	MeS	1-pyrrolidine	Methyl	Mass spectrum (m/e): 422 (M+1)
S-6	Ethyl	2-fluorophenyl	Methyl	Mass spectrum (m/e): 429 (M+1)
S-7	Ethyl	2-methylthiophenyl	Methyl	Mass spectrum (m/e): 429 (M+1)
S-8	Ethyl	2-methylthiophenyl	Isopropyl	Mass spectrum (m/e): 429 (M+1)

No.:	R <sup>1</sup>	A	R <sup>19</sup>	Data
S-9	MeS	2-cyanophenyl	Methyl	Mass spectrum (m/e): 452 (M-1)
S-10	Me <sub>2</sub> N	Thiophen-2-yl	Methyl	Mass spectrum (m/e): 432 (M+1)
S-11	Ethyl	Thiophen-2-yl	Methyl	Mass spectrum (m/e): 415 (M+1)
S-11	MeS	t-Butyl	CF <sub>3</sub>	Mass spectrum (m/e). 461 (M-1)

The ability of compounds of Formula I to potentiate glutamate receptor-mediated response can be determined by one of ordinary skill in the art. For example, see U.S. Patent No. 6,303,816. In particular, the following test may be utilized:

5 HEK293 cells stably expressing human iGluR4 (obtained as described in European Patent Application Publication No. EP-A1-0583917) are used in the electrophysiological characterization of AMPA receptor potentiators. The extracellular recording solution contains (in mM): 140 NaCl, 5 KCl, 10 HEPES, 1 MgCl<sub>2</sub>, 2 CaCl<sub>2</sub>, 10 glucose, pH = 7.4 with NaOH, 295 mOsm kg<sup>-1</sup>. The intracellular recording solution  
10 contains (in mM): 140 CsCl, 1 MgCl<sub>2</sub>, 10 HEPES, (N-[2-hydroxyethyl]piperazine-N1-[2-ethanesulfonic acid]) 10 EGTA (ethylene-bis(oxyethylene-nitrilo)tetraacetic acid), pH = 7.2 with CsOH, 295 mOsm kg<sup>-1</sup>. With these solutions, recording pipettes have a resistance of 2-3 MΩ. Using the whole-cell voltage clamp technique (Hamill et al.(1981)Pflügers Arch., 391: 85-100), cells are voltage-clamped at -60mV and control  
15 current responses to 1 mM glutamate are evoked. Responses to 1 mM glutamate are then determined in the presence of test compound. Compounds are deemed active in this test if, at a test concentration of 10 μM or less, they produce a greater than 10% increase in the value of the current evoked by 1 mM glutamate.

In order to determine the potency of test compounds, the concentration of the test  
20 compound, both in the bathing solution and co-applied with glutamate, is increased in half log units until the maximum effect was seen. Data collected in this manner are fit to the Hill equation, yielding an EC<sub>50</sub> value, indicative of the potency of the test compound. Reversibility of test compound activity is determined by assessing control glutamate 1mM responses. Once the control responses to the glutamate challenge are re-established, the  
25 potentiation of these responses by 100 μM cyclothiazide is determined by its inclusion in



both the bathing solution and the glutamate-containing solution. In this manner, the efficacy of the test compound relative to that of cyclothiazide can be determined.

In addition, certain behavioral despair animal models, which can be practiced by one of ordinary skill in the art to evaluate compounds of the present invention, are predictive of antidepressant activity in man, such as the Forced Swim Test and the Tail Suspension Test. For example, see "Experimental Approaches to Anxiety and Depression", Edited by J.M. Elliott, et al., (1992), John Wiley & Sons Ltd., Chapter 5, *Behavioural Models of Depression*, Porsolt and Lenegre, pages 73-85.

According to another aspect, the present invention provides a pharmaceutical composition, which comprises a compound of Formula I or a pharmaceutically acceptable salt thereof and a pharmaceutically acceptable carrier, diluent, or excipient. In addition, the present invention provides a pharmaceutical composition, which comprises a compound of Formula II or a pharmaceutically acceptable salt thereof and a pharmaceutically acceptable carrier, diluent, or excipient.

The pharmaceutical compositions are prepared by known procedures using well-known and readily available ingredients. In making the compositions of the present invention, the active ingredient will usually be mixed with a carrier, or diluted by a carrier, or enclosed within a carrier, and may be in the form of a capsule, sachet, paper, or other container. When the carrier serves as a diluent, it may be a solid, semi-solid, or liquid material which acts as a vehicle, excipient, or medium for the active ingredient. The compositions can be in the form of tablets, pills, powders, lozenges, sachets, cachets, elixirs, suspensions, emulsions, solutions, syrups, aerosols, ointments containing, for example, up to 10% by weight of active compound, soft and hard gelatin capsules, suppositories, sterile injectable solutions, and sterile packaged powders.

Some examples of suitable carriers, excipients, and diluents include lactose, dextrose, sucrose, sorbitol, mannitol, starches, gum, acacia, calcium phosphate, alginates, tragacanth, gelatin, calcium silicate, micro-crystalline cellulose, polyvinylpyrrolidone, cellulose, water syrup, methyl cellulose, methyl and propyl hydroxybenzoates, talc, magnesium stearate, and mineral oil. The formulations can additionally include lubricating agents, wetting agents, emulsifying and suspending agents, preserving agents, sweetening agents, or flavoring agents. Compositions of the invention may be formulated

so as to provide quick, sustained, or delayed release of the active ingredient after administration to the patient by employing procedures well known in the art.

The compositions are preferably formulated in a unit dosage form, each dosage containing from about 0.1 mg to about 300 mg, preferably about 0.1 mg to about 100 mg, and most preferably about 0.1 to about 50 mg of compound of Formula I or Formula II. The term "unit dosage form" refers to a physically discrete unit suitable as unitary dosages for human subjects and other mammals, each unit containing a predetermined quantity of active material calculated to produce the desired therapeutic effect, in association with a suitable pharmaceutical carrier, diluent, or excipient.

As used herein the term "patient" refers to a mammal, such as a mouse, guinea pig, rat, dog or human. It is understood that the preferred patient is a human.

As used herein, the terms "treating" or "to treat" each mean to alleviate symptoms, eliminate the causation either on a temporary or permanent basis, or to prevent or slow the appearance of symptoms of the named disorder. As such, the methods of this invention encompass both therapeutic and prophylactic administration.

As used herein, the term "effective amount" refers to the amount of a compound of Formula I or Formula II which is effective, upon single or multiple dose administration to a patient, in treating the patient suffering from the named disorder.

An effective amount can be readily determined by the attending diagnostician, as one skilled in the art, by the use of known techniques and by observing results obtained under analogous circumstances. In determining the effective amount or dose, a number of factors are considered by the attending diagnostician, including, but not limited to: the species of mammal; its size, age, and general health; the specific disease or disorder involved; the degree of or involvement or the severity of the disease or disorder; the response of the individual patient; the particular compound administered; the mode of administration; the bioavailability characteristics of the preparation administered; the dose regimen selected; the use of concomitant medication; and other relevant circumstances.

The compounds of Formula I or Formula II can be administered by a variety of routes including oral, rectal, transdermal, subcutaneous, intravenous, intramuscular, bucal or intranasal routes. Alternatively, the compounds of Formula I or Formula II may be administered by continuous infusion. A typical daily dose will contain from about 0.005 mg/kg to about 10 mg/kg of the compound of Formula I or Formula II. Preferably, daily

doses will be about 0.005 mg/kg to about 5 mg/kg, more preferably from about 0.005 mg/kg to about 1 mg/kg.

The dosages of the drugs used in the combinations set forth herein, must also, in the final analysis, be set by the physician in charge of the case, using knowledge of the drugs, the properties of the drugs in combination as determined in clinical trials, and the characteristics of the patient, including diseases other than that for which the physician is treating the patient. General outlines of the dosages, and some preferred dosages, are provide herein. Dosage guidelines for some of the drugs will first be given separately; in order to create a guideline for any desired combination, one would choose the guidelines for each of the component drugs.

Olanzapine: from about 0.25 to 50 mg, once/day; preferred, from 1 to 30 mg, once/day; and most preferably 1 to 25 mg once/day;

Clozapine: from about 12.5 to 900 mg daily; preferred, from about 150 to 450 mg daily;

Risperidone: from about 0.25 to 16 mg daily; preferred from about 2-8 mg daily;

Sertindole: from about .0001 to 1.0 mg/kg daily;

Quetiapine: from about 1.0 to 40 mg/kg given once daily or in divided doses;

Ziprasidone: from about 5 to 500 mg daily; preferred from about 50 to 100 mg daily;

Aripiprazole from about 1 to about 50 mg daily, preferred from about 5 to about 30 mg daily.

Fluoxetine: from about 1 to about 80 mg, once/day; preferred, from about 10 to about 40 mg once/day; preferred for bulimia and obsessive-compulsive disease, from about 20 to about 80 mg once/day;

Duloxetine: from about 1 to about 30 mg once/day; preferred, from about 5 to about 20 mg once/day;

Venlafaxine: from about 10 to about 150 mg once-thrice/day; preferred, from about 25 to about 125 mg thrice/day;

Milnacipran: from about 10 to about 100 mg once-twice/day; preferred, from about 25 to about 50 mg twice/day;

Citalopram: from about 5 to about 50 mg once/day; preferred, from about 10 to about 30 mg once/day;

Fluvoxamine: from about 20 to about 500 mg once/day; preferred, from about 50 to about 300 mg once/day;

Paroxetine: from about 20 to about 50 mg once/day; preferred, from about 20 to about 30 mg once/day.

5 Sertraline: from about 20 to about 500 mg once/day; preferred, from about 50 to about 200 mg once/day;

Donepezil: from about 1 mg to about 20 mg, once/day; with from about 5 mg to about 10 mg, once/day being preferred.

10 Rivastigmine: from about 1 mg to about 15 mg daily; with from about 5 to 12 mg daily being preferred;

Galantamine: from about 4 mg to 64 mg daily; with from about 4 mg to about 32 mg daily being preferred;

Memantine: from about 5 mg to about 30 mg/kg daily, with about 20 mg daily being preferred.

15

In more general terms, one would create a combination of the present invention by choosing a dosage of first and second component compounds according to the spirit of the above guideline.

20 The adjunctive therapy of the present invention is carried out by administering a first component together with the second component in any manner which provides effective levels of the compounds in the body at the same time. All of the compounds concerned are orally available and are normally administered orally, and so oral administration of the adjunctive combination is preferred. They may be administered together, in a single dosage form, or may be administered separately.

25 However, oral administration is not the only route or even the only preferred route. For example, transdermal administration may be very desirable for patients who are forgetful or petulant about taking oral medicine. One of the drugs may be administered by one route, such as oral, and the others may be administered by the transdermal, percutaneous, intravenous, intramuscular, intranasal or intrarectal route, in particular  
30 circumstances. The route of administration may be varied in any way, limited by the physical properties of the drugs and the convenience of the patient and the caregiver.

The adjunctive combination may be administered as a single pharmaceutical composition, and so pharmaceutical compositions incorporating both compounds are important embodiments of the present invention. Such compositions may take any physical form which is pharmaceutically acceptable, but orally usable pharmaceutical compositions are particularly preferred. Such adjunctive pharmaceutical compositions contain an effective amount of each of the compounds, which effective amount is related to the daily dose of the compounds to be administered. Each adjunctive dosage unit may contain the daily doses of all compounds, or may contain a fraction of the daily doses, such as one-third of the doses. Alternatively, each dosage unit may contain the entire dose of one of the compounds, and a fraction of the dose of the other compounds. In such case, the patient would daily take one of the combination dosage units, and one or more units containing only the other compounds. The amounts of each drug to be contained in each dosage unit depends on the identity of the drugs chosen for the therapy, and other factors such as the indication for which the adjunctive therapy is being given.

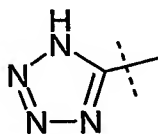
The inert ingredients and manner of formulation of the adjunctive pharmaceutical compositions are conventional, except for the presence of the combination of the present invention. The usual methods of formulation used in pharmaceutical science may be used here. All of the usual types of compositions may be used, including tablets, chewable tablets, capsules, solutions, parenteral solutions, intranasal sprays or powders, troches, suppositories, transdermal patches and suspensions. In general, compositions contain from about 0.5% to about 50% of the compounds in total, depending on the desired doses and the type of composition to be used. The amount of the compounds, however, is best defined as the effective amount, that is, the amount of each compound which provides the desired dose to the patient in need of such treatment. The activity of the adjunctive combinations do not depend on the nature of the composition, so the compositions are chosen and formulated solely for convenience and economy. Any of the combinations may be formulated in any desired form of composition.

As with any group of structurally related compounds which possess a particular generic utility, certain groups and configurations are preferred for compounds of Formula I and Formula II as set forth below.

With respect to substituent  $R^1$ , compounds wherein  $R^1$  is hydrogen, F,  $-OCH_3$ ,

-SCH<sub>3</sub>, CF<sub>3</sub>, -C(=O)CH<sub>3</sub>, methyl, or ethyl are preferred, with hydrogen, -SCH<sub>3</sub>, CF<sub>3</sub>, methyl, or ethyl being especially preferred, and with ethyl being most especially preferred.

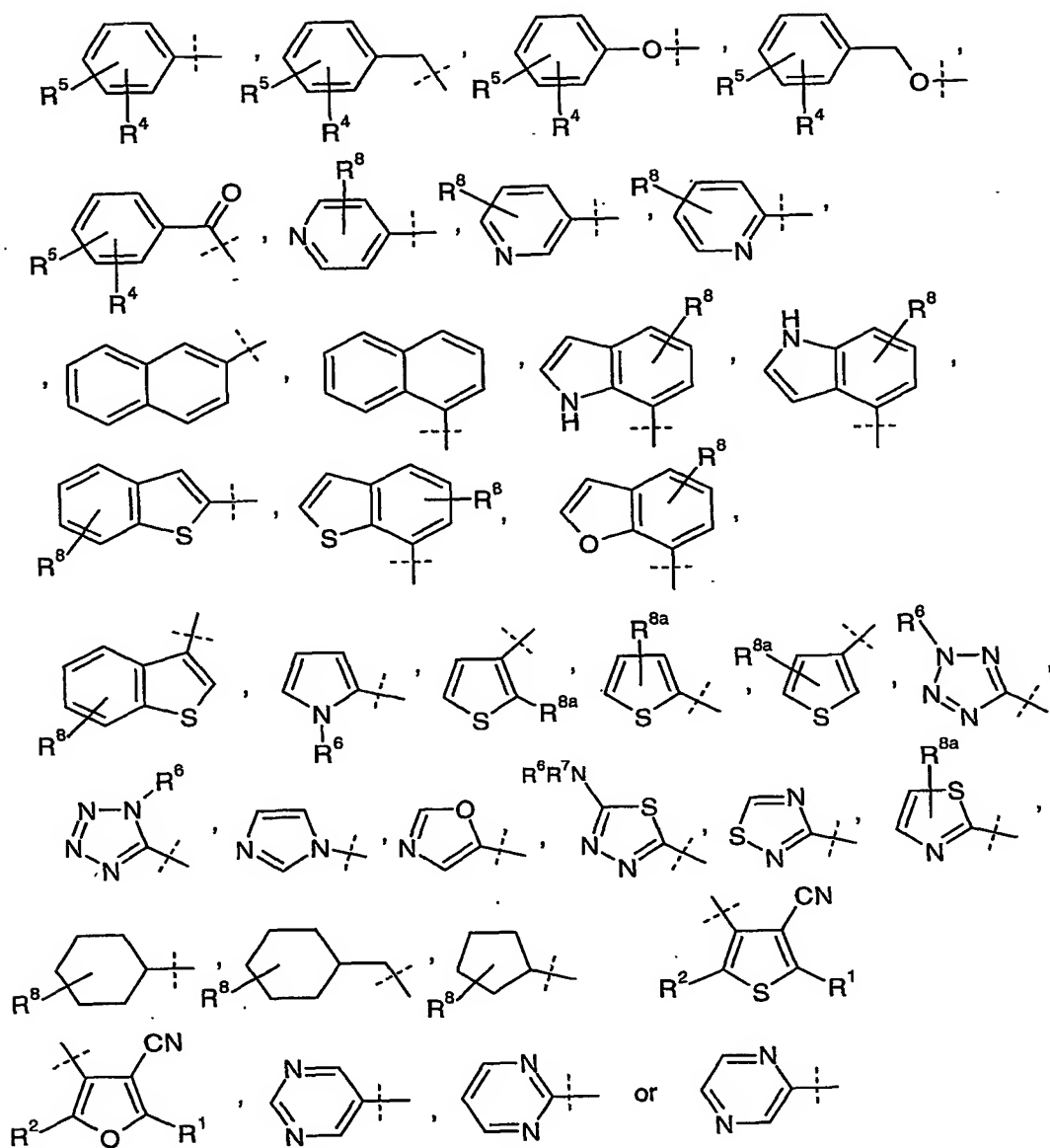
With respect to substituent R<sup>2</sup> in compounds of Formula I, compounds wherein is R<sup>2</sup> is -CO<sub>2</sub>H, -CONHSO<sub>2</sub>(1-4C)alkyl, or



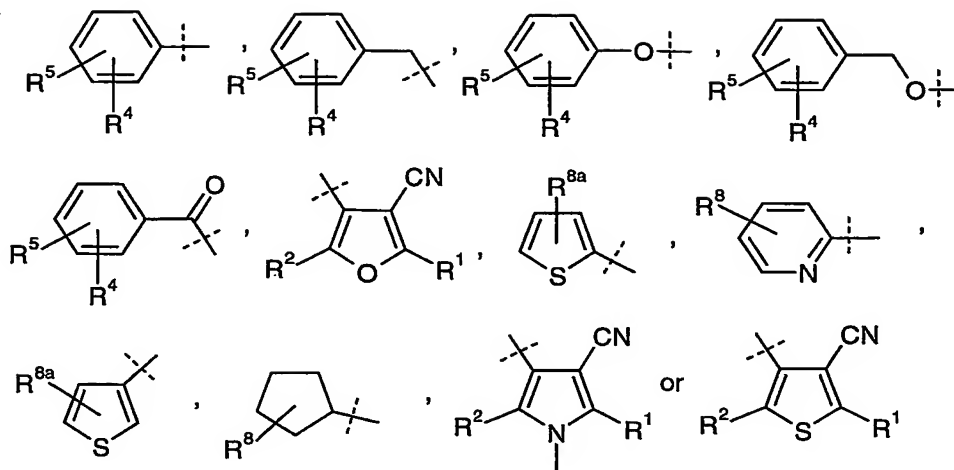
5

are preferred, with CO<sub>2</sub>H being especially preferred.

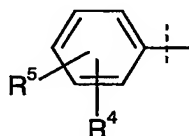
With respect to substituent A, compounds wherein A is ; -(CH<sub>2</sub>)<sub>m</sub>NHSO<sub>2</sub>R<sup>12</sup>, -CH(CH<sub>3</sub>)(CH<sub>2</sub>)<sub>p</sub>NHSO<sub>2</sub>R<sup>12</sup>, -(CH<sub>2</sub>)<sub>p</sub>CH(CH<sub>3</sub>)NHSO<sub>2</sub>R<sup>12</sup>, -O(CH<sub>2</sub>)<sub>n</sub>NHSO<sub>2</sub>(1-4C)alkyl,



are preferred, with  $-(CH_2)_2NHSO_2R^{12}$ ,  $-CH(CH_3)(CH_2)NHSO_2R^{12}$ ,  
 $-(CH_2)CH(CH_3)NHSO_2R^{12}$ ,  $-O(CH_2)_nNHSO_2(1-4C)alkyl$ ,



being especially preferred, and;



being most especially preferred.

5

With respect to substituent  $R^4$ , compounds wherein  $R^4$  is hydrogen, F, -(1-4C)alkyl, -(1-4C)alkoxy, -C(=O)NH(1-4C)alkyl, -NHC(=O)(1-4C)alkyl, -NHSO<sub>2</sub>R<sup>10</sup>, -CN, -CO<sub>2</sub>H, -C(=O)(1-4C)alkyl, or -S(1-4C)alkyl are preferred, and compounds wherein  $R^4$  is hydrogen, -(1-4C)alkoxy, -CN, or -S(1-4C)alkyl are especially preferred, and compounds wherein  $R^4$  is hydrogen, -CN, ethoxy, or -SCH<sub>3</sub> are most especially preferred.

10

With respect to substituent  $R^5$ , compounds wherein  $R^5$  is hydrogen, F, Cl, and -(1-4C)alkyl are preferred, with hydrogen, F, and methyl being especially preferred, and hydrogen being most especially preferred.

15

With respect to substituent  $R^6$ , compounds wherein  $R^6$  is hydrogen or methyl are preferred, with hydrogen being especially preferred.

With respect to substituent  $R^7$ , compounds wherein  $R^7$  is hydrogen or methyl are preferred, with hydrogen being especially preferred.

With respect to substituent  $R^8$ , compounds wherein  $R^8$  is hydrogen are preferred.



With respect to substituent  $R^{10}$ , compounds wherein  $R^{10}$  is (1-4C)alkyl are preferred with methyl, ethyl, or 2-propyl being especially preferred, and with methyl being most especially preferred.

5 With respect to substituent  $R^{11}$ , compounds wherein  $R^{11}$  is (1-4C)alkyl are preferred.

With respect to substituent  $R^{12}$ , compounds wherein  $R^{12}$  is (1-4C)alkyl are preferred, with methyl, ethyl, and 2-propyl being especially preferred.

With respect to substituent  $R^{13}$ , compounds wherein  $R^{13}$  is (1-4C)alkyl are preferred.

10 With respect to substituent  $R^{14}$ , compounds wherein  $R^{14}$  is (1-4C)alkyl are preferred, with methyl, ethyl, or propyl being especially preferred.

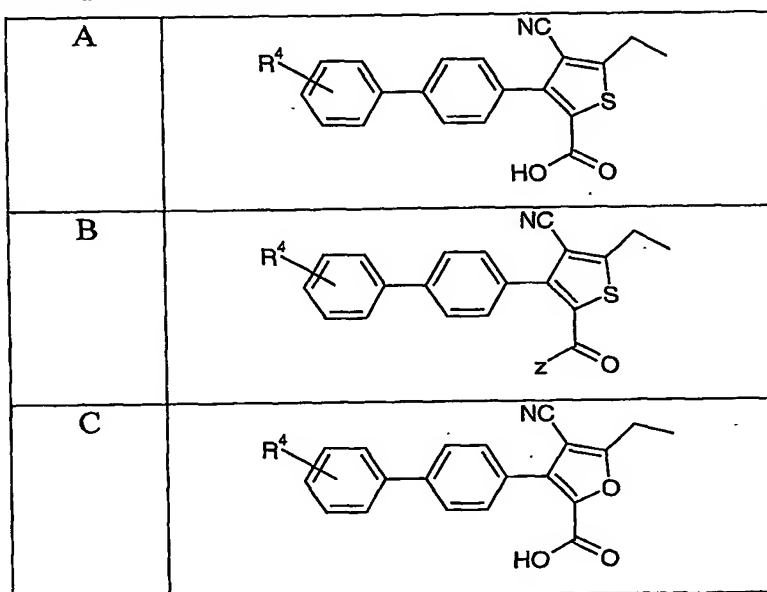
With respect to m, compounds wherein m is 0, 1, or 2 are preferred, with 2 being especially preferred.

With respect to n, compounds wherein n is 1 or 2 are preferred.

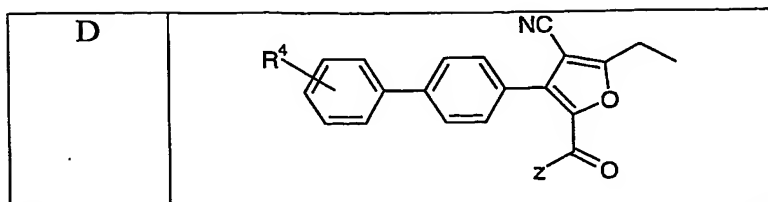
15 With respect to p, compounds wherein p is 1 are preferred.

With respect to substituent Z, compounds wherein Z is -O(1-6C)alkyl are preferred, with methyl, ethyl, propyl, and isopropyl being preferred, with ethyl being especially preferred.

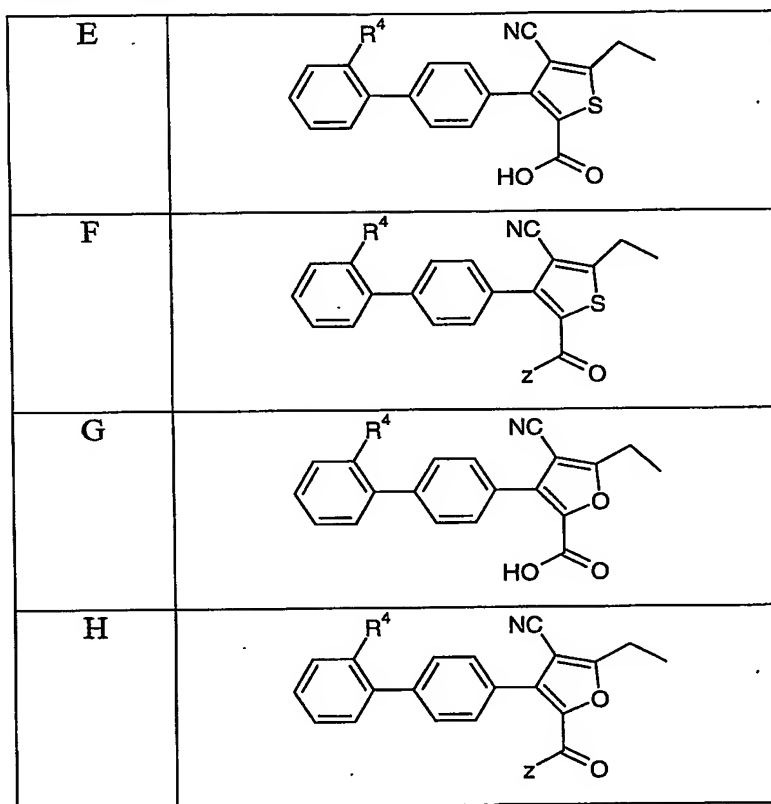
20 In particular, compounds of the following formulas and their pharmaceutically acceptable salts are especially preferred:



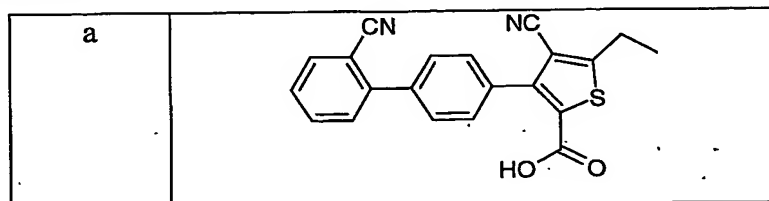
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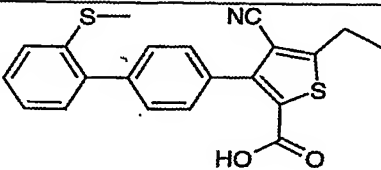
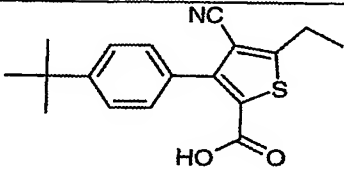
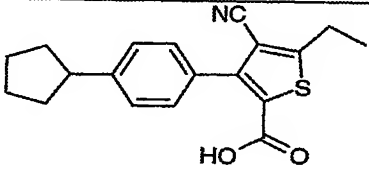
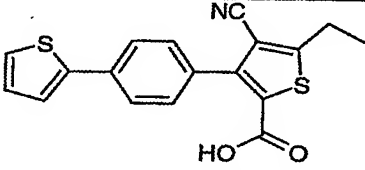
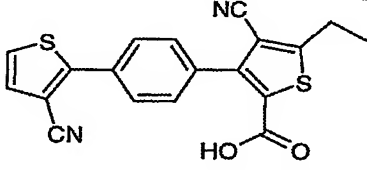
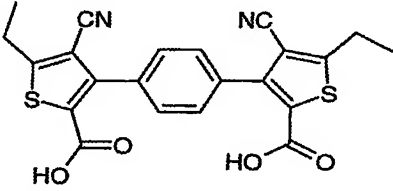
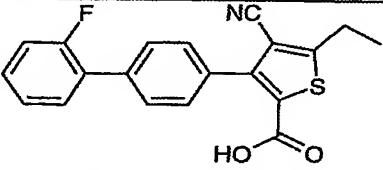
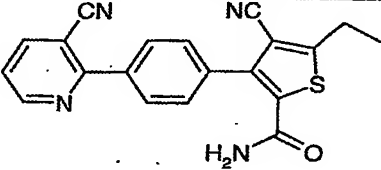


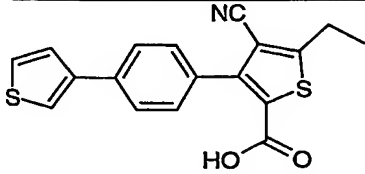
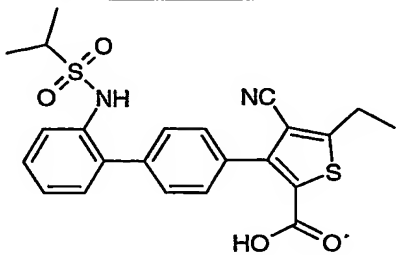
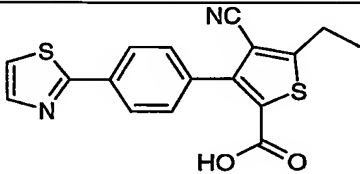
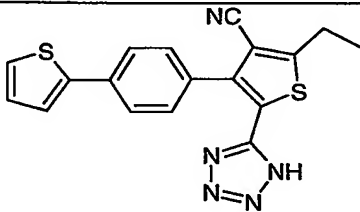
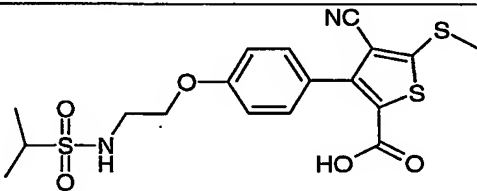
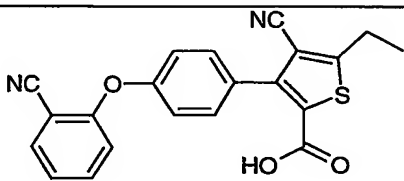
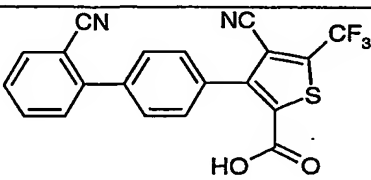
Compounds of the following formulas and their pharmaceutically acceptable salts are most especially preferred:



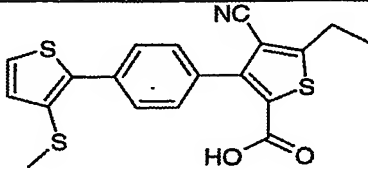
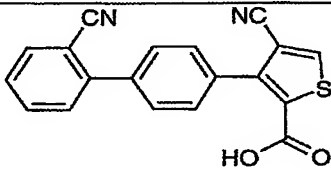
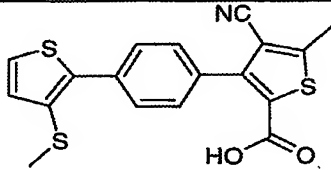
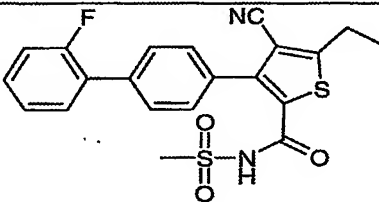
5 The following specific compounds and their pharmaceutically acceptable salts are particularly preferred:



b	
c	
d	
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f	
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h	
i	

j	
k	
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m	
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q	 <chem>CCc1sc(C(=O)O)c(C#N)c1-c2ccc(cc2)-c3ccsc3</chem>
r	 <chem>CC1=CC(=C(C=C1)C(=O)O)C(C#N)=C1C=C(C#N)C1-c2ccc(cc2)-c3ccccc3C#N</chem>
s	 <chem>CC1=CC(=C(C=C1)C(=O)O)C(C#N)=C1C=C(C)C1-c2ccc(cc2)-c3ccsc3</chem>
t	 <chem>CCc1sc(C(=O)NS(=O)(=O)C)c(C#N)c1-c2ccc(cc2)-c3ccccc3F</chem>